THE

ELECTRICAL REVIEW.

VOL. XXXI. AUGUST 12, 1892. No. 768

CONTENTS:

	PAGE
Twenty Years of Telegraphy in India	181
Some Primary Battery Tests	182
The British Association:—	
Presidential Address, Mechanical Section	184
A new Form of Windmill for Electrical and other Puposes	184
Experiments on Electrical Resistance	185
Secondary Batteries in Use at the Central Telegraph Office, London, for Telegraphic Purposes (*illustrated*)	186
The Application of Destructors, particularly to the Electric Lighting of Edinburgh	186
The Utilisation of the Energy of Flowing Water (*illus.*) ...	187
Electric Locomotives: Some Results in Actual Working	189
Destruction of Lightning Protectors by recent Municipal Legislation.—The B. A. Committee on Electrical Standards	192
Anti-Friction Materials for Bearings used without Lubricants	194
The Human Body as a Conductor of Electricity (*illus.*) ...	196
Prof. Ewing's Magnetic Curve Tracer (*illustrated*)	198
A Contribution to the Theory of the Perfect Influence Machine (*illustrated*)	199
Some Experiments with a Rhumkorff Coil (*illustrated*) ...	199
Sources of Heat Generated in the Galvanic Battery ...	200
Notes	200
Business Notices, &c.	204
City Notes, &c.:—City and South London Railway	205
Halifax and Bermudas Cable Company.—Traffic Receipts	206
A Contribution to our Knowledge of the Rhumkorff Coil Discharge.—The Electric Lighting of Brussels	207
The Current that Cures	208
The Electric Lighting of Frankfort	209
Chicago Exhibition	210
New Patents.—Abstracts of Published Specifications	210
Correspondence:—Incandescent Lamp Manufacture and Tests	211
Physiological Effects of High Frequency Alternating Currents.—Storage Battery Traction	212

J. A. BERLY'S

UNIVERSAL ELECTRICAL DIRECTORY

For 1892,

Sent free within the Postal Union for 4s., net.

ONLY A VERY FEW COPIES REMAIN IN STOCK

Scale of charges for Advertisements and Insertions, with examples of various insertions sent, post free, on application to

H. ALABASTER, GATEHOUSE & CO.,
22, Paternoster Row, London, E.C.

THE ELECTRICAL REVIEW.

Published every FRIDAY, Price 4d.

The Oldest Weekly Electrical Paper. Established 1872.

MAY BE OBTAINED BY ORDER FROM ANY NEWSAGENT IN TOWN OR COUNTRY.

OFFICE:—22, PATERNOSTER ROW, LONDON.

Telegraphic Address: "AGNEKAY, LONDON." Code A B C. Telephone No. 517.

ALL Letters should be addressed to the Proprietors, H. Alabaster, Gatehouse & Co.

ADVERTISEMENT RATES ON APPLICATION.

The "Electrical Review" is the recognised medium of the Electrical Trades.

SUBSCRIPTION RATES.—In *Great Britain*, Post Free, per Year, 19s. 6d. To all *Foreign Countries* (except those mentioned below), per Year, £1 1s. 8d. *Exceptions.*—Abyssinia, Aden, Borneo, Ceylon, India, Java, Labuan, Mozambique, Penang, Persia (*viâ* Brindisi), Phillipine Islands, Singapore, Zanzibar, to which the rates are: per Year, £1 3s. 10d.

BINDING.—Subscribers' numbers bound, including case, for 3s. 6d. each volume.

CASES.—Cloth Cases for Binding can be had, price 2s. 6d. each.

READING CASES, to hold from One to Twenty-six Numbers until the Volume is complete for Binding, can now be had from the Publishers, Price 6s., or Free by Post (in Great Britain), 6s. 6d.

FOREIGN AGENTS.—New York: D. VAN NOSTRAND, 23, Murray Street. *Paris:* VEUVE J. BOYVEAU, 22, Rue de la Banque. *Berlin:* ASHER & Co., 5, Unter den Linden.

Cheques and Postal Orders (on Chief Office, London) to be made payable to Mr. H. ALABASTER, 22, Paternoster Row, E.C.

TWENTY YEARS OF TELEGRAPHY IN INDIA.

THERE are few countries, perhaps, where the telegraphs are under State control, in which the administration can view with more satisfaction the growth of telegraphic traffic, and the daily increasing utility it affords in political and commercial operations as well as in social intercourse and in domestic affairs, than in India and Burma. Figures will best exhibit the expansion that has taken place, but to those who know India, the facts themselves connected with it will furnish much food for reflection. In the Telegraph Department in 1871 there were 15,000 miles of line, in 1891 37,000. The mileage in wire and cables 28,000 and 114,000 respectively. The number of offices of the Government Telegraph Department in 1871 were 200, and in 1891 (inclusive of those in post offices) 949; in addition, 75 were opened for temporary purposes. The number of messages received from the public for the official year ending 1871 was 632,000, and in 1891, 3,400,000, producing in revenue £160,000 and £517,000 respectively.

Two measures introduced during the last nine years, both due to the foresight of Sir Albert Cappel, late Director-General of Telegraphs, have very largely conduced to this immense increase. The first was the introduction of the eight anna (half rupee) tariff for messages classed "deferred," which would be despatched after the lines were clear of urgent and ordinary messages. Nearly half the traffic in 1890—91 was "deferred." This class is much resorted to by business men for their evening advices, which are intended to be dealt with by their correspondents in the early morning; and in an immense empire like India, such a telegram is, of course, able to anticipate the arrival of the post, for distances by rail over 300 miles, and in many far parts of the country, by a week. The price charged is low, and the moderate speed of transmission sufficient for the present needs of most communities in India. Hence the large use of this telegram.

Then the second measure, which no one can praise too highly, for the reasons we shall give, was the introduction of the combined post and telegraph office, such as exists in small country towns and villages in England.

Here the difficulty in framing such a system, by which the work of the public should be efficiently performed, was infinitely greater than would be experienced in Europe. In India the *employés* of the Postal Department could, in many small offices, understand little English, and were unacquainted with even the appearance of a telegraph instrument. A beginning was, however, made with telephones, a form of instrument which a native of India, owing to his excellent articulation, shows more aptitude in using than a European, and the success met with induced Sir Albert Cappel to carry on the scheme. Telephones could not be

used on long lines; on multiple circuits the Morse signals destroyed speech; and the atmospheric disturbances almost daily experienced on any wire of over a few miles in length, operated to drown the voice. The postal clerks were therefore, by degrees, instructed in Morse telegraphy, and though the standard of scholastic attainments among them was not high, still a competent knowledge of signalling operations was creditably acquired. We had, therefore, in 1891, as a result of Sir Albert Cappel's sagacity and perseverance, 689 telegraph offices worked by the Postal Department, but forming part of the general telegraphic system of the country. The Director-General had seen that no large increase in the facilities afforded to the public could be expected unless the extension of the telegraphs could be done at moderate expense; burdened in so many ways with financial claims, the Government was reluctant to open any new office with an expensive staff, unless adequate returns were guaranteed. The combined post and telegraph office exactly met the want of the age, and the cost, comparatively to that of a departmental office as it formerly existed, is something like one to four.

Now, every important country town in India is either on the telegraph system or within easy reach of it, and most places of 1,000 inhabitants are asking for telegraph offices. The extension which Sir A. Cappel inaugurated has encouraged trade, because it has given the native merchant the means of concluding speedy contracts, and of learning where he will find profitable markets. At the same time it must, of course, be admitted that railways have stimulated production, and have given him the means of putting his goods quickly into the large markets. A liberal rearrangement of tariffs will probably enable Mr. Brooke, the present Director-General of Telegraphs in India, who has been so instrumental throughout his long service in making the department what it is, to see last year's figures doubled before his term expires.

In addition to the number of offices given above, there were in India and Burma, in 1891, 3,100 railway and canal offices open to the public. The Government Department maintained 1,666 of these offices, 16,000 miles of posts and 40,000 miles of wire for railways and canals.

SOME PRIMARY BATTERY TESTS.

SOME interesting tests have recently been conducted by W. G. Miller and W. H. Foster, of the School of Mechanical Engineers, Illinois, U.S.A., upon several primary batteries. Three of these batteries, the "Gonda," the "Gonda porous cup," and the "Mesco," were of the so-called "open circuit" class; that is to say, they were adapted to stand on open circuit and to generate a current at intervals of a few seconds only, without loss or waste. The other was of the type known as the "Taylor," and was a "closed circuit" battery, which works on a closed circuit for a considerable time, through a small resistance, with very little change in the strength of the current.

The method used in these tests was that known as the condenser method, which consists in charging a condenser with the battery, and then by means of a discharge key discharging this charge through a high resistance galvanometer. Since the capacity of the condenser remains constant, the deflections of the galvanometer will be proportional to the electromotive forces, and by comparing these deflections with that given by the known electromotive force of a standard cell, the electromotive forces are ascertained. A Carhart-Clark standard cell, having an E.M.F. = 1·441 volts, was used for this purpose. The potential difference was determined in a similar manner. To determine the rate of change caused by polarisation, the circuit was kept closed through a known resistance and the potential difference read at definite intervals. The E.M.F. was also taken at intervals by breaking the circuit long enough to charge and discharge the condenser. The rate of recovery was obtained by noting the E.M.F. at intervals after the circuit is open. A one-third microfarad standard condenser and a Thomson's square-pattern high resistance galvanometer, were used in carrying out these tests.

The results obtained by Messrs. Miller and Foster are illustrated by curves showing at a glance the exact E.M.F., potential difference, internal resistance, and current, of the battery under consideration, at any time during the tests. From these curves we may glean the following particulars:—

For the "Gonda porous cup" the E.M.F. commences at 1·63 volts, and during the first ten minutes drops 0·35 volt, and then the polarisation is gradual to the end of the test, when the E.M.F. is 1·195 volts. The recovery shows a rapid rise during the first six minutes after the opening of the circuit, when it increases more slowly in value, and, after three-quarters of an hour, is still 0·14 volt less than the initial E.M.F. The terminal potential difference decreases in E.M.F. about the same rate as the polarisation from 1·29 volts down to 0·97 volt. The current is quite regular, and averages 0·2 ampère.

In the case of the "Gonda" type of battery, the polarisation is more continuous, and does not decrease so suddenly. The potential difference is also nearly continuous from the start, while the internal resistance is smaller than in the "porous cup." The recovery shows a gradual increase until the end of the test, when it is but 0·04 volt less than the initial E.M.F. The current is very regular, the total fall being but 0·03 ampère, showing a very steady current for an "open circuit" battery.

The "Mesco" dry battery represents a good type of this class of battery. The polarisation decreases slowly from 1·5 volts to 1·37 volts, and recovers leisurely to 1·45 volts. The potential difference decreases leisurely from 1·41 volts to 1·265 volts. There is an increase in internal resistance. The current gradually decreases, and the fall during the test was 0·03 ampère, making an average current of 0·26 ampère.

The Taylor battery was given a most severe test, being in circuit 28 hours. It started with the high E.M.F. of 1·86 volts, and the current was 1·38 ampères. After 15 minutes these had fallen only to 1·8 volts and 1·2 ampères, while for the next 12 hours they remained perfectly constant. This shows how well this battery is adapted for mining motors, &c., where a high E.M.F. and a large current are required to be constant for a considerable length of time. The curve of "external energy" shows the comparative constancy of output for the first half of the test. The internal energy is large throughout, showing a mean of about 0·6 watt, while the maximum external energy is but 2·05 watts. This large loss of energy internally, as compared with the external

energy, is due to the high internal resistance, being at least 0·5 ohm for all but the first 15 minutes, while the external resistance is but a little over 1·0 ohm. This shows that the battery would be more efficient when used with higher external resistance. The recovery is very rapid, the battery recovering upon the opening of the circuit 0·4 volt in a few minutes, while it finally reaches its voltage at a constancy of 1·8.

It is well to notice, in connection with these results, that the makers recommend that the solutions of the battery be no longer used after they show a certain loss in density; but this was disregarded by Messrs. Miller and Foster, in order to see what the results would be. What the results were are represented by curves, and show a rapid decrease in all but the internal resistance.

The Crystal Palace Exhibition.

Whatever the commercial results of the Crystal Palace Exhibition are expected to be from a manufacturer's point of view, there can be little doubt that the Crystal Palace Company must regret their endeavours of providing a show of electrical apparatus. At the recent yearly meeting of the company it was shown that a decided loss had accrued from holding the exhibition. It was estimated that a sum of £7,344 had been spent, and the sum that could be really credited in the way of receipts was £6,400. It might be just well to mention, by the way, that it is difficult to realise why so much has been spent, considering that each provided his own stand as well as light. When we consider this loss, one naturally looks back to the reasons which led to the Exhibition. We expressed our doubts as to the usefulness of such an exhibition when the matter was first suggested, and during the period when it was held we saw no reason to alter our opinion. It was claimed that a collection of electrical plant would do much towards enlightening the public as to the real status of electricity, and that it would also form a sort of technical training for town councils in the North of England. Of course, it is easy to make such presumably laudable desires the means of putting money into certain pockets, but the weakness of such arguments is only too palpable. We do not wish for one moment to detract from the merits of the exhibits, for no one admired them more than we, but we feel regret that money was spent on an exhibition which has proved to be a failure, and more especially do we regret this expenditure in face of the fact that English manufacturers show no desire to take part in the Chicago Exhibition. This apparent apathy may, to a great extent, be due to the leading manufacturers taking so prominent a part in the recent Crystal Palace Exhibition.

Hoisting the Danger Signal.

A short time ago, at a meeting of the North of England Institute of Mining and Mechanical Engineers, the subject of electricity in its application to coal mining was under discussion, and various advantages and disadvantages were energetically canvassed. Amongst the latter it was stated, by one prominent speaker, that leakage of current into water would produce large quantities of electrolytic gas, which would be a dangerously explosive factor in the atmosphere of the mines. He enlarged upon the instability of this gas, and attributed to it ignition properties which, we think, no chemist would substantiate. We do not remember that his statements were at all controverted, or that it was even suggested that the dangers which he so graphically pictured were over estimated. In view of this it is interesting to notice a recent research by A. Krause and V. Meyer, whose claims to be heard will be recognised by every physical chemist. They found (*vide Annalen*, cclxiv. p. 85) that when moist electrolytic gas is heated at 305° C. for two weeks, that very slow combination takes place between the oxygen and hydrogen. The temperature of explosion of electrolytic gas was found to lie between 518°—606° C., but when slowly passed through a glass tube it does not explode at 606° C. More recent experiments by F. Freyer and V. Meyer (*vide Berichte*, xxv., p. 622), place the explosive point still higher, namely, between 650°—730° C. Of course, it may be urged that these are "only laboratory experiments," but still it must, we think, be conceded, in view of these results, that statements concerning the danger of liberating electrolytic gas in coal mines should be made a little more cautiously, so that wrong impressions may not be conveyed, tending to prejudice coal owners against having electricity applied in their pits. But, conceding the explosive violence of electrolytic gas in large quantities, how many cubic centimetres are going to be liberated before an escape of electricity is discovered? And cannot escapes be entirely prevented with careful installation?

Pure Platinum.

It has been pointed out to us that the leaderette in our last issue, referring to certain statements put forward in a German publication on the subject of "Pure Platinum" should not remain without comment, lest they might be handed down and accepted as historically correct. Whoever has ingeniously elaborated this absurd myth that hitherto most of the platinum employed has been contaminated with "iridium, rhodium, palladium, iron, copper, silver, lead, osmium, and gold," must, if such is really his experience, have confined himself to some very circumscribed area for his samples, as the platinum refined in England, France, and America, is certainly not open to this indictment. Irrespective of the fact that the "secret" for preparing pure platinum in the manner indicated happens to be a well known laboratory process publicly mentioned by a Belgian professor more than 20 years ago, there are other superior and far more practical and economical methods of refining this metal by which tens of thousands of ounces are every year produced in England of the highest possible degree of purity, whilst it would be interesting to know how many pounds or even ounces of "absolutely pure" platinum have ever been obtained by this so-called German "trade secret." The inference which is evidently intended to be drawn by this ridiculous notice, viz., that the Germans excel other nations in the purity of the platinum they produce, is as unjust as it is contrary to the generally accepted experience of the largest consumers of this metal. *A propos* of this question, it may be of interest to state, as a proof of what can be done *even* outside of Germany, that a quantity of upwards of 250 kilos. (8,000 ozs.) of platinum supplied some years since by the firm of Johnson, Matthey & Co., of London, to the French Government, for the manufacture of the International Standard Weights and Measures (every ingot of which was analysed by the celebrated chemists, MM. H. St. Clair Deville and Debray, of Paris, and Mr. Stas, of Brussels—certainly the greatest living authorities on platinum analysis—who were selected as Experts by the International Committee), was officially declared to contain of pure platinum 999·98773 in every 1,000 parts. There does not appear to be much margin here for contamination by any of the 10 above named impurities. Such statements as those to which our article drew attention, whether or not put forward for advertising purposes, tend to bring ridicule, if not discredit, upon the large body of scientists of high standing of which the German nation may so justly be proud.

THE BRITISH ASSOCIATION.

PRESIDENTIAL ADDRESS, MECHANICAL SECTION.

PROFESSOR UNWIN makes a very suitable and fitting president this year to the Mechanical Science Section of the British Association, for, although not actually engaged in practical mechanical engineering, he has always appeared, more than many of the professors, to keep in touch with practical questions, and to build upon a broader foundation than many others.

The connection of the British Association with mechanical science bears about the same relation to, say, the Institute of Mechanical Engineers as should the professor to the engineer.

Touching lightly in his presidential address upon civil engineering in its restricted meaning with a reference to the great works in connection with the water supply of Liverpool, Manchester, and New York, Mr. Unwin gave an admirable *resumé* of the present condition of the science and practice of steam engineering in which he gathered with wonderfully few words many loose strings into one cord, and he did not forget to give strong accent to the great advantage which would attend any thoroughly trustworthy method of superheating steam. He summed up the efficiency of the best steam engines at 9 per cent. This included the boiler. Gas and oil engines had an efficiency double this, from which it would appear that the gas engine as a whole is not very much superior to the steam engine apart from the boiler.

But the main body of the address had reference to the conveyance of power from place to place. This is a branch of mechanical engineering that will present probably many new features and illustrations for the next few years.

A century ago saw the rise of the cotton trade, and the solution of the motive-power problem was then found in water-power, hence the location at Cromford of Arkwright's first cotton mills, but this involved a wide scattering of the mills, often in places difficult of access, and it involved, too, the almost baronial dominance of the mill-owner over the workers who could not readily change their place of work. It was not until the beginning of this century that Watt's improvements on the steam engine took firm hold, and resulted in all new factories being built in the towns, and this crowding of huge factories into streets and along the lines of the canals with a closely packed population of workers in the worst of dwellings hard by had produced a state of affairs worse than that which had prevailed in the water-power days.

Prof. Unwin now takes a leap of 80 years, and shows that even in 1880 there was in the United States a total of 3,400,000 horse-power used in manufacturing operations, of which 36 per cent. is obtained from water. At the present day Switzerland pays £800,000 annually for foreign coal. She uses 80,000 horse-power from waterfalls out of a total of 582,000 available, and a year ago the professor found nearly every large industrial concern in Switzerland preparing to use water-power from a distance; and besides great schemes carried out at Schaffhausen, Bellegarde, Geneva, and Zurich, there is a project to develop 10,000 horse-power near Martigny on the Dranse.

Needless almost to remark, that though he did not fail to enumerate what had already been effected by the Swiss with wire rope transmission of moderate powers to distances of less than a mile; with water, as introduced by Lord Armstrong, and so successfully worked in London by the Hydraulic Power Company, who have already over 50 miles of pressure mains, and in addition to other work are actuating no fewer than 1,500 lifts, or with compressed air so eminently suited for mining and quarry work, Mr. Unwin had in his mind the latest and best system of electrical transmission. Perhaps it is because in England fuel is so plentiful and water-power of but small amount, that the list of power transmission schemes nearly all hail from the Continent or America. At Oyonaz, 300 H.P. from turbines is transmitted 8 kilometres at 1,800 volts and sold for lighting and power purposes, and at the Calumet and Hecla mines on Lake Superior and the Dalmatia Mines in California, distances of a mile or two are compassed and energy transmitted from turbines.

At Schaffhausen, electricity is working parall-l with the wire-rope system, and the power developed sold at 60s. per horse-power.

The water supply for the City of Genoa has a fall of 2,050 feet, and the surplus fall generates 1,600 horse-power, which is transmitted 16 miles by bare copper wires of 8½ millimetres diameter.

The utilisation of power from turbines at Lauffen, transmitted 108 miles to Frankfort at a tension of 18,000 to 27,000 volts, with an efficiency of, often, 70 per cent., is still fresh in memory, and Mr. Unwin inclines to the opinion that given durable and efficient transformers, the alternate current system will be found best, especially as low tension producers and low tension motors are likely to be more mechanically unexceptionable than those working with or producing high voltages. At Geneva and at Zurich, the dynamos supplying electric light are driven by water which has first been pumped to a high service reservoir, a system somewhat circuitous, but possessing advantages in these cases because of the small and variable fall available for driving the original turbines, which are large, cannot run at constant speed, and are suitable for driving pumps, which they do for 24 hours daily. Hence the system is not without certain economical features.

So successful already has electrical transmission proved itself, that it has been held to warrant that huge scheme now nearly complete at Niagara, an available power of 7 million horse, or double the total steam and water-power at present used in the United States is there to be drawn upon. Water to the amount of 265,000 cubic feet per second descends 326 feet in 37½ miles.

The present plans contemplate the utilisation of only 100,000 horse-power, and the chief work has been the construction of a tunnel of 386 feet cross-sectional area and 7,250 feet long, as a tail race for the turbines to the river below the fall. Though the original plans involved the distribution of water direct to mills which would discharge into the large tunnel, it is obvious that Niagara is a field for electrical transmission, and already arrangements are in progress to transmit 3,000 horse-power to Buffalo, 18 miles distant. Steam-power in Buffalo costs $35 per annum. For large powers the cost of electrical-power will be probably only $10. Americans are apt to think Niagara the greatest waterfall on the planet; but there is reason to believe that Africa takes the lead; and if electrical science progresses as rapidly as it has done in the recent past, the prospects of utilisation of water-power are indeed brilliant. American ingenuity will find its full exercise in Niagara; the intelligence of Europe has a bigger field before it in its own territory and in that immense continent of Africa of which the resources are as yet untouched. When our coal has given out, we may still continue to live in England and have power and heat sent us from abroad. We cannot but congratulate Prof. Unwin upon his exceedingly interesting address.

A NEW FORM OF WINDMILL FOR ELECTRICAL AND OTHER PURPOSES.

By Professor J. BLYTH.

(*Read August 5th*, 1892, *before Section G.*)

AT the present time the employment of the form of energy known as the electric current to industrial purposes has become very extensive; and, in the near future, its application in that direction is likely to be still further increased. We have already many large private installations of the electric light. Every steam boat of any size is now electrically lit. In many places the current is used for the transmission of power. Already several large towns have adopted it instead of gas for street lighting, and the question of general house-to-house lighting is one whose solution only awaits a slightly greater economy in current production and distribution. It may be said that as yet the current is generated almost exclusively by dynamos driven by steam engines; so that it is merely a transformation of the potential energy of coal, and, so long as this is the case, it is obvious that any cheapening in its production can only arise either from an increase in the efficiency of the dynamo or of the steam engine, or of both. Now these machines have attained so great an efficiency that there is scarcely any hope for much improvement in this direction. Primary batteries of several forms have been suggested and tried, but currents got from the oxidation of metals will always, I think, be too dear for practical purposes. Something may be expected from thermo-electric batteries, for here we have the direct transformation of heat into current electricity without the intervention of the wasteful middleman represented by the steam engine and dynamo. This, however, can hardly be said to have reached even the experimental stage.

Considerations such as these have led electrical engineers to look about and see if there may not be some other source of power at present unused, and which might be utilised for current production. Naturally water-power first suggests itself. The Niagara Falls have often been spoken about, and their available energy for that purpose calculated. In several places electric lights are run from water-wheels where the fall happens to be near at hand, but in the great majority of cases the available falls of any size are so far from the centres of population that the cost of conducting the current almost prohibits their use. Much, no doubt, may be done by employing rapidly alternating currents of high voltage, and so diminishing the cross section of the necessary leads but even then, when the distance is considerable, the cost of conduction comes in as a serious item. And besides, water-power is not free. Although a fall may be unused just now, still when it is proposed to use it, it immediately acquires a money value and must either be rented or bought outright.

Next, after water-power, comes the consideration of wind-power; and it is about this that I am principally to speak. The wind is proverbially free, and is to be had everywhere, although it is of a very intermittent nature. Up till recently, this entirely precluded its use for current generation, as it was obviously impossible for it to work electric lights or do any kind of work where a steady current at a fixed time was required. But all this has been changed by the invention of storage cells or accumulators. These are now highly efficient, though a little too expensive; but disregarding the expense, we are now able to store any quantity of electric energy and get a high return, even although a considerable time elapse between the storing and the using of it. No sooner was the accumulator invented than windmills for electric storage began to be thought of. At the York meeting of the British Association, Sir William Thomson suggested the construction of cheap windmills to run dynamos for charging accumulators, but, so far as I know, no practical trial was made till the summer of 1887, when I erected my first electric windmill in the village of Marykirk, Kincardineshire. At that time I procured a set of 13 accumulators and constructed a windmill of the old English type, having four arms and canvas sails. The length of the arms was about 14 feet, and the sails were 8 feet by 3 feet. The mill was provided with bevelled gearing at the top, a vertical shaft, and bevelled gearing below, so arranged that the driving wheel moved always in the same vertical plane, no matter in what direction the wind shaft pointed. The mill was turned into the wind by hand, having no tail or other gearing for keeping automatically head to wind. The dynamo was driven by a belt from the driving wheel, and with this I was able on two or three windy days to store my cells. Although the experiment was not on a very large scale, it was sufficient to show me that accumulators could quite well be charged, when the electrical connections were properly made, by a dynamo driven at the irregular speed characteristic of a windmill. Sails I found were not a great success, especially since I had no way of reefing them. To prevent them being torn to pieces.

the mill had to be stopped when the wind was high, that is, just at the time when it should have been going at its best.

I remedied this partially. I altered the wind-wheel from the English to the American type, having a number of arms and blades of sheet-iron. I also introduced the further improvement of doing away with the driving-wheel being always made to go in the same plane. This is absolutely necessary if the windmill is to drive a saw-mill, a corn-mill, or anything of that sort, but for electrical purposes the dynamo can quite easily be attached to the wind-shaft platform so as to turn with the mill as the wind changes. In this way all gearing is avoided, as the dynamo can be driven by ropes from a large wheel keyed directly on to the wind-shaft. This I found to answer very well so long as the wind had a moderate speed, but like all other windmills, I soon found that it had either to be made self-reefing or stopped altogether when a breeze came. This is obviously very unsatisfactory, as the best of the wind for storage purposes is lost, and hence this problem presented itself, viz., how to construct a windmill that would satisfy the following requisites:—

1. It must be always ready to go.
2. It must go without attendance for lengthened periods.
3. It must go through the wildest gale, and be able to take full advantage of it.

A possible solution of the problem is presented in the Robinson anemometer, which consists of four hemispherical cups attached to four arms, and moving in a horizontal plane about a vertical axis. From the theory of this instrument, which is however only approximate, it appears that whatever might be the speed of the wind, the speed of the cups attained a certain *terminal* value, such that the couple due to the wind pressure was exactly equal to that produced by the resistance to the motion through the air, and the friction on the bearings.

Last summer I erected a machine of this kind, which has been considerably improved within the past three months. The cups are replaced by semi-cylindrical boxes attached to four strong arms, each about 26 feet long—the opening of each box is 10 feet by 6 feet, and the vertical shaft is a long rod of iron 5 inches in diameter. At the lower end it carries a massive *pit* wheel, which actuates a *train of gearing*, and drives a flywheel, 6 feet in diameter, with the requisite speed for driving a dynamo connected with it by a belt in the ordinary way. This machine worked most satisfactorily, and with a fair wind speed, gave about 2 electrical horse-power. I also tested it in a strong gale, by allowing it to run with no load, and the result was perfectly satisfactory, as a safe terminal speed was attained, and all racing avoided. Hence I think that electrical windmills, at least for small installations, are likely to assume this form, as there is no limit to the size and strength with which they may be constructed, and, if necessary, several could be placed in any well exposed position, each having its own dynamo and set of accumulators. During the past few months I have increased the power of the machine by adding an auxilliary box to each arm with a gap between it and the previous one. This I find to be better than merely increasing the size of the previous box. As the whole is a case of vortex motion, the theory is very difficult. Information can only be got from models and applying the principle of dynamical similarity.

Regarding the electrical connections necessary I may say a word. All that is needed is that the circuit be broken when the dynamo is running at less than the storage speed. This is easily managed by a governor attached to the dynamo shaft, and which makes and breaks contact in a mercury pool at the required speeds. I have also tried a form of governor which *throws* a greater or less number of cells into the charging circuit as the wind varies, and in this way the machine is always doing some work.

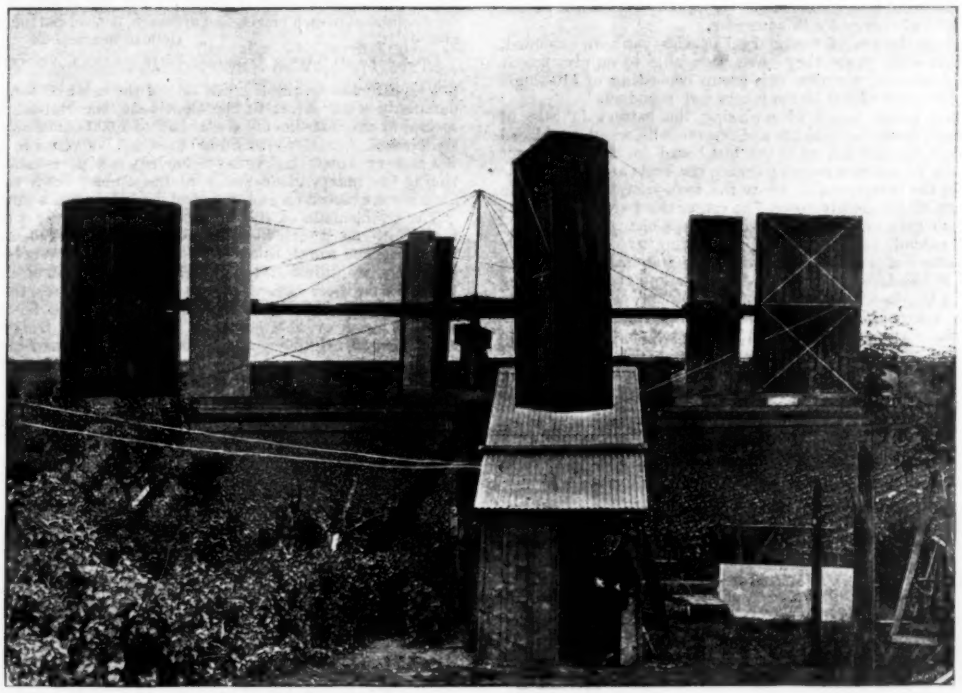
We may next turn to the uses for which windmills are specially applicable. These are:—

1. *For Lighting Lighthouses.*—These are always in exposed situations, where wind is plentiful, and often in such out of the way places that stores and coal for generating the electric light in any other way could only be sent with difficulty.

2. *For the Lighting of Private Country Mansions.*—Here, whatever form of power is used, accumulators must be provided. The wind, I think, specially recommends itself, from its cleanly nature, if it can be applied without the trouble of much attendance.

3. For factories so situated that a suitable mill could be placed on the roof, and thus be in an exposed situation.

In closing, I may just refer to the probability that the present system of electric lighting by incandescence will be superseded by some method of getting light from cold sources. When we think that 99 per cent. of the energy spent in a gas flame is waste, as far as light is concerned, that a percentage almost as high in the electric light is also waste, we are strongly tempted to think that lighting by incandescence cannot be a final form. Recent discoveries have distinctly proved that rapidly oscillating currents send out waves exactly similar to light waves, but only having a much greater wave length. Attempts have been made to get alternate current machines of such frequency as to send out such waves. Should these be successful, then light will be generated with much less expenditure of energy, and windmills even of very moderate power may be all that is required. I can quite easily fancy the time coming when each house has its own little windmill storing current, which may be used to drive such machines as those alluded to, and giving a light suitable for the house. We should not require to drive large steam engines in order merely to let us see each other or read a newspaper.



Prof. Blyth's New Form of Windmill.

EXPERIMENTS ON ELECTRICAL RESISTANCE.

By Dawson Turner, M.D.

(*Read August 5th before Section A*)

The author had the pleasure when in Paris of seeing some of Mr. E. Branly's experiments on the influence of currents of high potential upon electrical resistance. He has since repeated some of these. It is well known that metallic powders present a very great electrical resistance. This can be lowered to an extraordinary degree by the passage of a spark in their neighbourhood. The author has tried, amongst other substances, powdered aluminium, copper, annealed selenium, iron filings, small shot, mixtures of aluminium and resin fused into a solid stick, &c. The best results were obtained with the first two. A short glass tube is filled with powdered aluminium, and placed, by means of copper wires passing through corks, in circuit with one or two cells and a galvanometer. The resistance of the aluminium is very great, and the needle of the galvanometer will remain at zero. If, however, a spark from an induction coil be passed anywhere in the vicinity, the resistance will become at once very much diminished, and the galvanometer needle will be deflected. Thus, though there was

at first no appreciable current, there may now be one of 250 milliampères. The powder will, if undisturbed, remain a conductor for some little time; but if the table be shaken, or the glass tube be moved, the initial resistance at once returns, and the needle passes back to zero. After the resistance has been once lowered in this way, the powder gets into a very sensitive condition—a spark at a great distance lowers the resistance, and the slightest jar restores it. The author was not successful with ordinary iron filings, perhaps because they were not sufficiently finely divided. Mere shaking does not restore the resistance of the solid stick of aluminium and resin, but the application of a little warmth is sufficient.

The experiments would appear to suggest that the molecules of the powders become arranged in such an order as to conduct electricity, when an electrical discharge occurs in their neighbourhood, and that the slightest mechanical jarring suffices to destroy this arrangement. It does not appear to matter which way the induction current is passed.

SECONDARY BATTERIES IN USE AT THE CENTRAL TELEGRAPH OFFICE, LONDON, FOR TELEGRAPHIC PURPOSES.

By W. H. PREECE, F.R.S.

(*Read in Section G, August 8th.*)

IN a paper entitled "The Use of Secondary Batteries in Telegraphy," communicated to the British Association at the meeting held in Montreal in 1884, I gave an account of a series of experiments which had been carried on during the preceding twelve months, to determine the suitability of secondary batteries for telegraphic purposes. In the same paper, after giving a number of calculations as to the financial side of the question, I ventured to predict that secondary cells would soon be made the most economical of the sources of electrical energy for this purpose.

Since that time the use of secondary batteries has been extended, and for the past seven years they have been able to supply current to two large groups of circuits, one group consisting of 110 single needles, and the other of 100 Morse inkers and sounders.

To provide a ready means of replacing the battery in case of failure, the leads from the working and reserve cells, which are placed in the basement, are first led up to the test-board in the instrument room, and there joined to a switch; thence the leads are again led to a test-board in the battery room, where the two groups are split up into sub-groups of 10 circuits each. The connections are made in this manner for two reasons, first, for facilitating a change of a faulty battery; and second, to prevent a general stoppage of the whole group in the event of a short circuit at any of the instruments; the resistance of the leads between the instruments, and the sub-dividing connections in the basement being sufficient to prevent more than three ampères being taken from the battery by any one of the instruments, even when a short circuit is on. To prevent any damage to the instruments, or risk of fire, fuses are placed in the battery leads at each instrument. The circuits on the groups mentioned are all metropolitan, and are all, approximately, of the same resistance, no equalising resistances being, therefore, necessary. The current in each circuit ranges between 17 and 20 milliampères. The E.M.F. for the single needles is 20 volts; 10 cells positive and 10 cells negative, with earth in the centre. For Morse working, the E.M.F. is 18 volts. The connections are shown in fig. 1.

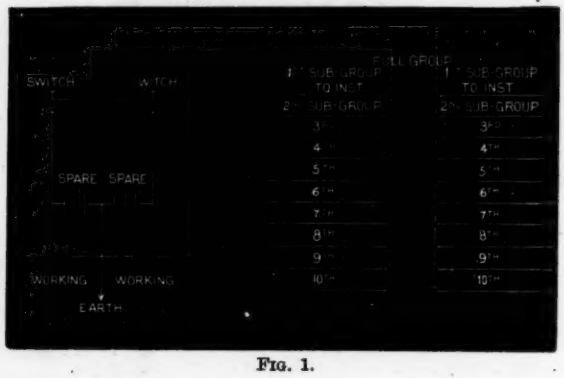
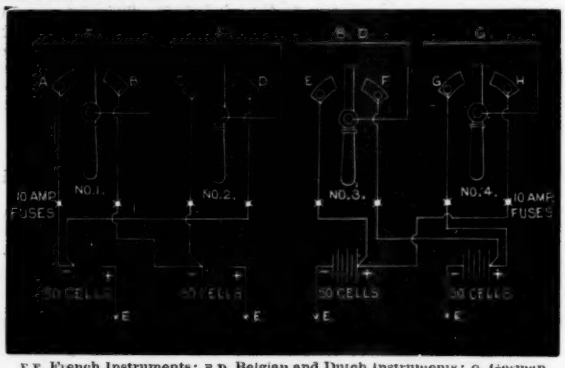


FIG. 1.

In addition to these two groups, another set of 22 cells has been in use since 1889, supplying current for driving the motors of the Delany multiplex distributors. Each of these motors requires a current of about 0·12 ampère, and there are ten of them at present driven from this source. Fuses are placed in the leads to each motor. There is no spare set for this work. A considerable extension of the accumulator system has recently been made, advantage being taken of the transfer of all the Continental service to the General Post Office building in St. Martin's-le-Grand. This transfer was made on October 17th, 1891, and since that date the whole of the Continental circuits have been operated by currents from secondary cells. There are 59 of these Continental circuits, and as they are of various lengths, some requiring repeaters in England, whilst others go direct to the Continent, a somewhat different arrangement has been adopted. In addition to these varying conditions, it was found impossible to use the same polarity to all countries. The German, Dutch and Belgian lines taking positive, and the French negative. It was also necessary to provide an arrangement which would cause the stoppage of the minimum number of lines should a main fuse be burned or a battery fail.

The 59 lines are divided into four groups, but as the force required for these long lines is 100 volts, it is evident that the risks of allowing a dangerously heavy current passing out from the instrument to line, should it make earth near the sending station, is increased. To provide against this, resistances of 100 ohms are placed in the battery leads at each instrument, so that it is absolutely impossible that more than 1 ampère can flow even with earth on the line close up to the instrument. Independent 3-ampère fuses are also fitted to each instrument, to prevent any damage to lines or instruments, should the safety resistance be short-circuited. As it is sometimes necessary to



F F, French Instruments; B D, Belgian and Dutch Instruments; G, German Instruments *viâ* North Walsham and Lowestoft.

100 ω resistance in each branch lead to French, Belgian and Dutch Instruments.
1,000 ω " " " " German Instruments.

FIG. 2.—CONNECTIONS OF SECONDARY CELLS FOR THE CONTINENTAL GALLERY.

put repeaters in on the English side of the cable on some lines which nominally work direct to the Continent, the resistance blocks on several of the instruments are wound to 1,000 ohms, and fitted with a switch which enables either 100 ohms or 1,000 ohms to be inserted in the battery circuit, and thus the current is kept constant. In addition to the independent 3-ampère fuses, main fuses to break at 10 ampères are placed on each group of circuits in the accumulator room.

The arrangement of the connections in use on the continental lines is shown in fig. 2. All the cells are kept well charged, and the E.M.F. is not allowed to fall below 1·95 volts per cell. Where spare or reserve sets are provided, the charging is carried on at any convenient time, and on those, where no spare sets are in use, the charging is done at night, when the minimum disturbance is caused by the slight increase of E.M.F., which is inseparable from simultaneous charging and working. Accumulators are also used for working the Paris telephone circuits. Their E.M.F. is so constant that they are found to be eminently adapated for the purpose.

THE APPLICATION OF DESTRUCTORS, PARTICULARLY TO THE ELECTRIC LIGHTING OF EDINBURGH.

By PROF. GEORGE FORBES, F.R.S.

(*Read before Section G., August 4th*, 1892.)

THE object of this paper is to enable the citizens of Edinburgh to see the enormous natural advantages which exist in their city with relation to electric lighting; advantages which they have not been fully aware of up to the present, but which must be taken advantage of at a very early date. The advantages are such that they will enable the people of Edinburgh to obtain the electric light at a price lower than gas, which can hardly be considered possible in any other town. The author began by saying a few words in regard to the history and prospect of electric lighting in Edinburgh. A few years ago the city of Edinburgh, unfortunately for its own interests, purchased the gas factories, entailing upon them the payment of a perpetual dividend of 10 per cent. to the shareholders of the gas company. At the time when that was in contemplation, he, the author, was in Edinburgh, and he wrote a letter to the leading daily paper on the subject, pointing out that by this act they were probably preventing themselves from gaining ultimately the benefits of electric light when it became a useful commodity. A leading article appeared in that paper which stated, in reference to the letter, that it had been conclusively proved that Edinburgh was one of those towns which the electric light did not suit, and that appeared to be a sufficient answer. However, the views of the citizens and municipal body of Edinburgh had materially changed since that time, and every effort is to be taken to introduce the electric light in the best and most economical manner. The present subject was divided into two heads; first about the use of destructors, that is, the use of furnaces for burning the city ash-bin refuse, which are very largely used and recognised as the best way of getting rid of refuse, and the means of using these destructors for fuel to generate steam so as to be able to apply it directly to the generation of electricity, but that was one part of the subject which was to be very fully treated by a paper to follow. Referring to any load diagram of an ordinary central station, they would find that during the greater part of the day the machinery and boilers were lying idle; for two hours only were they working at their maximum. To have these dynamos and engines standing without earning any money was very serious, but there was another serious result, and that was that the boilers required to be fixed up for simply a two hours' run. Every engineer knew what a low efficiency there would be from coal used in that manner. The only cure for this difficulty was some

system of storage. The president of the section had referred to the storage by means of hydraulic accumulators, which Lord Armstrong has so largely introduced; he has also alluded to storage—hydraulic storage in reservoirs—both at Geneva and Zurich. It was exactly following out those ideas that the author would suggest how the difficulty of storage should be overcome in Edinburgh. The reason why Edinburgh was peculiarly well situated was, that there was very high land in the immediate neighbourhood of the town—he referred specially to Arthur's Seat. The author's first notion was to use Dunsapie Loch as a reservoir, the idea being that a steam engine should be used at the low level, continually pumping water up to the high level, and at the lowest part of this, pipes and turbines should be attached for driving dynamos; this arrangement was exactly the same as that employed at Zurich. A further examination and consideration of the locality showed that by a slight additional expense they gained enormous advantages. Looking from the summit of Arthur's Seat, in the direction of Portobello, there is a gully which by means of a very short dam would enable them to make a reservoir which would not be in the least unsightly to the neighbourhood of Edinburgh, and, in fact, would be invisible save from the Portobello side of the hill. If such a dam were built, the pipe line would then be taken down to Lochend nearly a mile distant. The height of the reservoir would be 725 feet, and the height of Lochend 83; they might also use Dunsapie Loch and St. Margaret Loch, in fact, there were several ways of doing the work. If Dunsapie were deepened to 10 feet, it would contain a million and a quarter cubic feet of water, but by building a dam near the summit of Arthur's Seat, they got a quantity of water equal to 28,000 H.P. working for an hour, that is on the assumption of 75 per cent. efficiency on the turbines and pipes. The cost of the pipes carried from the summit of Arthur's Loch came out at the rate of £1 per horse-power. They would be able to see what could be done with this horse-power. The author would give three facts taken from central stations all over Europe, but especially from the Berlin works. The Berlin load curves showed that the maximum demand on a mid-winter day was four times the mean; second, if engines were constantly supplying power, storing what was not wanted, the storage capacity must be equal to maximum output working for about two hours; thirdly, the maximum output at any moment in the year was about six times the mean output of the whole year. Working from these facts, the author found that there can be obtained from the 28,800 H.P. hours available in the reservoir, a maximum output in the central station of 12,500 H.P., and that 3,000 continually working in the form of steam engines, would make a total of 15,500 H.P. There is by this means saved the cost of 12,000 H.P. boilers and engines which would probably cost £200,000, replacing it by pipes and turbines, pumps and reservoir, probably costing not more than £35,000 altogether. Pumping engines and turbines are now so perfect that it would be possible to get a horse-power delivered from 3 lbs. of Welsh coal. Experience showed that, including the coal wasted in getting up steam and banking fires, even when using the best appliances of the modern central station, 5 lbs. of coal at least is required for every horse-power. There is then a saving of about 2 lbs. of coal per horse-power by keeping the engines working at their maximum. The maximum demand in winter is six times the mean of the year; thus, with a maximum of 15,625 H.P., there is a mean output of 2,600 H.P. all the year round. A saving of 2d. per lb. of coal per H.P. amounted to 20,000 tons, which at £1 per ton meant a saving of about £20,000 per year. These facts illustrated very clearly the enormous advantage of storage, which could be so easily gained by utilising the natural advantages of the City of Edinburgh. The author then dwelt on the advantages of the use of destructors. There was no doubt that the use of destructors for getting rid of refuse, and for getting up steam for electric lighting purposes, will play an important part in the future, but in most towns it would be impossible to get the full advantage from the destructors, because they must be burning refuse day and night, whereas for electric lighting purposes, or the distribution of power, it was only during certain times of the day that there was a demand, so that the heat from the destructors was wasted for the greater part of the day; but by the hydraulic storage in Edinburgh, they would be able to use destructors with the greatest advantage. After a reference to the destructor at Leeds, the author said that steam had not been largely used at Leeds, but at Southampton and one or two other places it had been largely used. At Southampton the boilers (locomotive) are simply placed in the main flues, without any attempt to drive the products of combustion through the flues, with the consequence that there was a very bad economy, and it required 75 lbs. of ash-bin refuse to give a horse-power for one hour. The author had made numerous experiments on the heating properties of ash-bin refuse, and there is not the slightest doubt that in the great majority of towns the ordinary ash-bin refuse as a heat-producing power would mean that 10 lbs. would equal 1 lb. of ordinary coal. After a little advice as to the best means of utilising the heat for boilers, the author concluded by saying that we wanted an inventor to come forward with some means of storage which would enable boilers and engines to run at their full efficiency for 24 hours.

THE UTILISATION OF THE ENERGY OF FLOWING WATER.

By F. PURDON and H. E. WALTERS.

(Read before Section G, August 5th.)

THE energy of falling water has long been employed for motive purposes, and there is a widespread opinion that one of the great problems of the future is the conversion also into useful work of the immense power now running to waste in river and tidal currents. The authors believe that the discussion of any practical means of securing even a moderate portion of this force will be of considerable interest.

It is not necessary before this Association to dwell upon the economy effected by the use of water power where it exists under favourable conditions.

A rough general measure of the commercial value of water as compared with steam power would be the price paid for water rights.

Notwithstanding the natural advantage of water-power, there are often difficulties in its application which diminish its commercial value. Chief among these are—(1) That a fall cannot always be obtained in the place where its power could be most conveniently used with regard to markets and centres of trade, and (2) the irregularity of the supply of water owing to flood and drought, which renders the power inconstant.

These drawbacks and the steady improvement of the steam engine gradually led many people to believe that water motors were inconvenient, old-fashioned, and doubtfully profitable things, and attention was more and more given to the development and improvement of heat engines to the neglect of the older water machines.

Of late years, however, various causes have combined to revive the importance of water-power:—

(A) The frequent discussion as to a probable diminution of the coal supply in this country.

(B) The large working cost of the steam engine pressing upon manufacturers in keen competition, and often with narrowing margins of profit.

(C) The rapid development of electricity for lighting and other purposes, with its demand for power at a cheaper rate, and

(D) Perhaps most of all, that the electrical engineer has begun to succeed in transmitting energy easily and cheaply to a distance from the source of power, and storing it for use as required.

The effect is visible in the large capital expenditure incurred in many places in impounding water under favourable conditions and distributing its energy.

Instances will occur to many members of the Association, such as at—The Falls of Schaffhausen, on the Rhine; Geneva, on the Rhone; Tivoli, for the supply of electric light to Rome; Holyoke, in Connecticut; the experiments at the Frankfort Exhibition; the great scheme now in course of construction for attaching and distributing power from the Falls of Niagara, and many others.

Such natural sources of power in this country are very limited in extent, though, on the other hand, opportunities for using tidal power are more numerous.

In many estuaries some useful work is now obtained from this source in transporting barges, and it may be interesting to notice that on the flood tide a vessel is, in effect, moved by flowing water up a gradient.

Work is also done by the tide in lifting vessels lying at anchor through the height of its range, though this serves no useful purpose. It is estimated that in lifting a ship of 2,000 tons through a range of 20 feet, the continuous effort is equal to 7½ horse-power.

The most effective method known for using tidal power, from an hydraulic point of view, is to impound the water and work turbines on the ebb.

In general, however, the great capital cost for works to impound the water, and the further outlay for secondary reservoirs at high level, or other means for securing a constant power, render commercial success in this direction so uncertain, that little has yet been attempted on a large scale, although where the configuration of the land and other considerations are very favourable, schemes propounded for using tidal power in this way may, and probably will, be successful.

Some measure of the quantity of water that it is necessary to impound in order to obtain any large amount of power, may be gathered from the calculation that with a tidal range of 20 feet, it would require a reservoir of one acre in extent to obtain 25 horse-power for eight hours a day.

But there is another, though hydraulically less effective, method of obtaining useful work from rivers and tides in the many cases where moderate power only is required, or where the local conditions and great capital cost prohibit the construction of impounding works, namely, by using the energy of the *flow*.

In non-tidal rivers this force is of course continuous, and even in estuaries and tidal channels, in ordinary circumstances, it is available for about 16 hours a day on ebb and flood.

It is found that the total energy of a stream varies as the *cube* of the velocity, and that the pressure exerted against a plane surface at right angles to the direction of motion varies nearly as the *square* of the velocity or equivalent head.

Table A has been prepared from well-known formulæ, and shows the pressure per square foot, the equivalent head in feet and in inches, and the total energy per square foot of sectional area, for velocities from 1 to 6 miles an hour, which will be sufficient to cover the case of most currents.

TABLE A.

Velocity of stream.		Equivalent head.		Pressure.	Total energy.
Miles per hour.	Feet per second.	Feet and decimals.	Inches and decimals.	Lbs. per square foot.	H.P. per square foot sectional area.
1	1·467	·033	·43	2·1	·0055
2	2·933	·134	1·62	8·4	·0445
3	4·4	·300	3·60	18·9	·15
4	5·867	·534	6·42	33·6	·355
5	7·333	·834	10·07	52·5	·694
6	8·8	1·200	14·39	75·6	1·2

It becomes obvious from these calculations that, in a stream of small sectional area and low velocity, the total energy of flow at any point of section will be very small, and practically, that useful work by means of current motors is only to be looked for in streams having a high velocity or large sectional area with less speed.

The pressure of flowing water upon a blade may be compared to that of wind upon a sail, and it is seen that in a moderate breeze a sailing ship carries a large spread of canvas, but the vessel is propelled only at the same speed as may be attained with a much smaller sail area in a higher wind.

It may also be noticed here that sailing vessels of large size, exposing enormous sail area—up to 50,000 square feet and upwards—are still built, that they are easily handled, and successfully compete with steamers in many trades.

As far as the authors are aware, the floating wheel is the only current machine, requiring no permanent works, which is in actual use. This is merely an undershot wheel, generally of antiquated design, slung between two barges moored in the stream. The blade area exposed to the water is very limited, mainly from practical considerations of size and weight of the wheel, and rarely exceeds 15 square feet, and in consequence the machine is only to be found on rapid streams, as parts of the Rhine, Danube, Douro, and the like. Even under the best conditions the power to be obtained from it is very small. The most effective speed for the paddles is found to be about half the velocity of the current, and as the wheel moves in the same direction and away from the water impinging on the paddles, the wasted energy is very large. Being convinced that the essential conditions of any practical improvement in floating current motors are:—

(1) That the sectional area of stream entering the machine should be large;

(2) That the line of motion of the blades or paddles employed should not be in the direction of the stream.

A large number of tests were made at even intervals of time, and the results carefully tabulated. The velocity of the current was tested by an Amsler-Laffon current meter, and observations were taken every five minutes during the experiments. The power of the machine was measured on a brake-wheel, and in a current of 3 miles per hour was found to be 2½ horses, or about 11 per cent. of the total energy of the steam passing the blades.

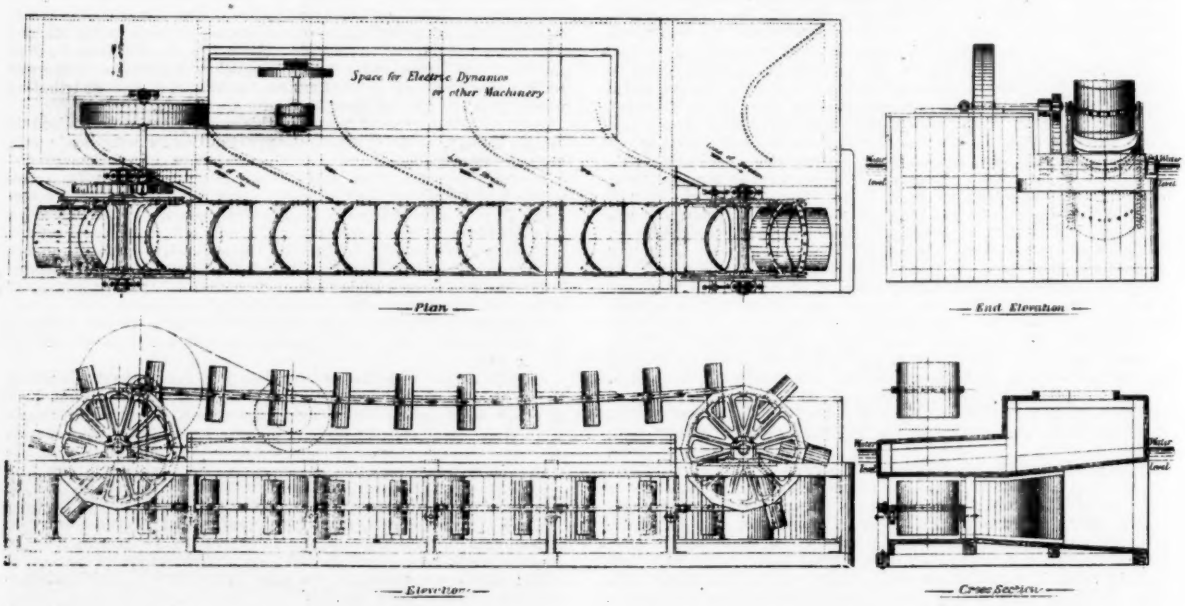
From the calculations of Prof. Unwin, it appeared that, though no exact theory of such a motor in an open stream can be formulated, the hydraulic efficiency, neglecting friction, might be 32 per cent., so that there was a loss of 21 per cent. due partly to the imperfect action of the water on the blades, and partly to mechanical friction of the chain and gearing.

The results of the experiments were encouraging; for, although the actual efficiency was low, it was at least as high as that of any other current-motor, while it had been demonstrated that a machine could be contrived, water borne throughout, to absorb the energy of a much larger sectional area of stream than had ever been before attempted, and on a principle capable of easy extension to great size. The machinery had worked smoothly throughout the tests, and considerable experience had been gained as to the behaviour of water acting upon completely submerged paddles in an open stream.

It was evident that the friction of the chain and gearing was excessive, and could certainly be reduced, and there was every reason to expect that a motor could be designed having the advantages of this machine, but with such improvements in the vanes and reduction in friction as to give an actual efficiency of 25 per cent.

The efficiency, however, of such a motor is only important in so far as it affects the cost of production of a horse-power—because, unlike the case of the turbine and other machines working under definite head, where efficiency is all-important, there is here no competitor.

The authors, therefore, having the great advantage of the advice and friendly criticism of Prof. Unwin, designed a new motor—plan,



The authors designed and had constructed an experimental motor (diagram plan and cross-section of which are exhibited), which was moored in the tideway of the Thames at Woolwich, where, in the autumn of last year, a series of tests were made under the direction of Prof. W. Cawthorn Unwin, F.R.S., the distinguished President of this Section.

This machine may shortly be described as follows:—

Two barges, each 50 feet long by 10 feet 6 inches wide, are braced together with an open channel, 5 feet wide, between them. In this, and above the water level, is fixed an endless iron railway, tilted to an angle of 45 degrees with the horizontal. Round this track travels, on wheel carriages, a pitch chain, articulated so as to pass easily round the curves at either end. The pitch chain carries 29 blades, each 4 feet wide by 3½ feet deep, 12 of which are always completely immersed in the water under the barges. The barges are moored at an angle of 60 degrees to the direction of the current, and the blades are fixed at right angles to the stream, and at 30 degrees to the direction of motion. The blades are arranged in "echelon," and in this way a blade area 151·6 square feet is exposed to the action of the water.

The current impinging on the blades moves the pitch chain, which gives motion to three pitch wheels, also geared together, and these drive an oblique shaft, which again, by bevel wheels, drives a horizontal shaft.

The effect of tilting the track, is that, while 12 of the blades are always vertically in the water, 12 are horizontally in the air (as shown on the cross-section), and the remainder are on curves at either end of the track—no provision for feathering is necessary, as the position of the track causes the blades to enter and leave the water in a very perfect manner. The blades, which are flat, have a square lip, 8 in. deep, on the leading edge, and a roof board of the same width on the top.

section, and elevation of which are exhibited. This machine is of much simpler construction than that before described, and differs from it widely in detail, but not in the essential principles before stated.

This motor, when at work, is moored at right angles to the direction of the current, so that, in proportion to its length, the greatest possible sectional area of stream is dealt with.

The machinery is carried on a single pontoon, underneath which a lower deck or platform is firmly attached, and while protecting those moving parts which are submerged from damage, it allows of the motor taking the ground, and even being worked in that condition.

The blades are fixed at even intervals to an endless chain, passing over and gearing with two vertical end wheels, instead of rolling round a rail track, so that the great weight and friction of the wheel carriages are avoided, and the gearing is immensely simplified.

The bearings for the wheel shafts are placed at such a level on the pontoon that half the chain and blades are submerged in the water, while the other half are suspended in the air. To keep the chain straight in the water and to resist side pressure, fixed guiding rollers are provided at short intervals.

The back portion of the pontoon is constructed with a water-tight deck interposed between the wheels and the two parts of the chain, so that, when the current imparts motion to the chain, those blades which are submerged have a clear passage between the lower platform and the pontoon, and are free to return in the air above.

The remaining portion of the pontoon is open, and carries the gearing and machinery to be driven.

The ends of the pontoon are boarded up outside the wheels carrying the chain, to permit of the motor being towed without damage to the blades.

The space between the pontoon and the lower platform, through which the current has to pass from the front of the motor to the

blades at the back, is in the form of a bell-mouth, contracted laterally by means of a curved wing vane at each end, and vertically by the inclination of the bottom of the pontoon and the lower platform.

In this space the current is diverted into the line of action of the blades, which is at right angles to the stream, by means of curved guide vanes, and the blades are also curved to receive the pressure of the water, and allow of its free escape into the stream beyond.

The whole arrangement is, in fact, designed approximately on the principle of the turbine.

The object of the bell mouth is to concentrate the energy of the large sectional area of stream entering the machine on to a comparatively small blade area, and at a higher velocity than the natural flow of the current, the advantage being the further reduction of the weight and consequent friction of the moving chain and blades, and the increase of initial speed of the driving wheels, with corresponding lessening of weight and friction of the gearing.

One of the end wheels is provided with spur gearing, revolving a second motion shaft, from which any higher speed for driving machinery is obtained by belts and pulleys.

The shaft of the other end wheel revolves in bearings which are set in a guide frame, and can be adjusted by screws to take up wear or slackness in the chain.

In a tidal current the motor would be allowed to swing at slack water in the ordinary way, and be hauled into position for the next tide. In the case of rivers, of course no change of mooring will be required.

TABLE B.

Sectional area, 151·6 square feet.

Velocity of stream.		H.P. of stream.	H.P. of a machine at 25 per cent. efficiency.
In miles per hour.	Feet per second.		
1	1·467	0·84	—
2	2·933	6·74	1·68
3	4·4	22·75	5·68
4	5·867	53·94	13·48
5	7·333	105·29	26·32
6	8·8	182·02	45·50

Table B has been prepared to show the power of a motor of this construction, taking the efficiency at 25 per cent. The sectional area at the bell-mouth is 151·6 square feet, or equal to that of the experimental machine. For a bell-mouth of this area, 4 feet deep, a pontoon 40 feet long by 11 feet wide would be sufficient, but this must not be taken as indicating the limit of size or even the most economical proportions of the machine.

From the figures in the table, a simple proportion will give the area at the bell-mouth for any required power.

For example, if 40 horse-power is required from a stream of 4 miles per hour:

151·6 square feet is to the area required as
13·48 is to 40 or 450 square feet.

Such a machine would require a pontoon 75 feet long and 6 feet deep at the bell-mouth, and would be no larger than an ordinary barge moored in an estuary.

It is clear from Table B that the cost per horse-power must depend almost entirely upon the velocity of the current, as the capital, outlay, maintenance, &c., is, within wide limits, nearly constant.

It is estimated that a machine 40 feet long, as above, can be constructed for £300.

In a moderate stream of 3 miles per hour it is expected that it will develop at least 5 horse-power.

Taking interest, maintenance, and depreciation at 12½ per cent., the annual cost per horse-power would be £7 10s., leaving out the cost of attendance, which, however, in hydraulic machinery is very low.

There are no steam engines of small power, even in this country where coal is not dear, which work at anything like so small a cost. In cases such as pumping, where the work could go on night and day, the annual cost of the steam horse-power would be more than doubled, but the cost of the hydraulic motor would not be increased.

If considerable power is required, several motors can be arranged in series at near intervals.

The authors are convinced that there is a large field for the employment of this motor. It is eminently suitable for pumping water for irrigation, the charging of accumulators, and other purposes, and for the storage of electricity in secondary batteries for the many uses for which these are employed. It has the advantage of being easily moved from point to point on a stream, for its temporary hire for agricultural and other work, where permanent power is not required.

A useful application would be to construct the machine in connection with the pontoons of floating bridges, where these exist, which could be done at small cost, and the sale of power made to assist the revenue derived from tolls. Such revenue, when added to the tolls, might even permit of the construction of these bridges in places where the traffic estimate would not otherwise justify the capital outlay.

Favourable places for the employment of the motor, both in this country and abroad, will at once occur to many members of the Association. Wherever the floating mill is now used, the suitability is undoubted—as the Rhine, Danube, Douro, and others. To these may be added the great rivers of North and South America, Africa, and India; tidal estuaries, as at Liverpool, Plymouth, Portsmouth, Hull, and many more; and channels, such as the Menai Straits, where it was lately said, by Mr. W. H. Preece, F.R.S., in an interesting lecture upon "The Waste Forces of Nature," there was a power of 6,000 horses, if only it could be used.

In conclusion, the authors do not claim to have done more than touch the fringe of the question of converting the great tidal energy around us into useful work. They venture to hope, however, that they have indicated a means whereby the energy of flowing water may be effectually used without the erection of permanent works, even in currents of moderate velocity, and that a large field exists for its profitable employment.

DISCUSSION.

Mr. KILLINGWORTH HEDGES, contrary to the opinion of most people, had found from several instances which he had examined, that it was difficult to obtain power from water. Work in connection with water-power should be very solidly done, and he alluded to the adverse influence of those having properties adjoining the sources of water-power.

Sir FREDERICK BRAMWELL said that to utilise the power of the rise of the tides was generally too expensive to make it worth while. He was consulted at Bristol on this question, and he found that it would not commercially pay until coals became something like £4 per ton. He thought that with reference to the scheme proposed, a large wheel, with suitable buckets, should do the work, and would not have the same defects of friction as the chain, but it would doubtless be necessary to have a wheel very large in diameter.

Prof. OSBORNE REYNOLDS alluded to the important consideration of such resistances placed in streams, say in tidal estuaries, practically damming the water out.

Mr. HEAD thought they must take care not to discourage inventions bearing on the utilisation of water-power, at the same time in our country it was fast becoming more valuable for other purposes than for obtaining power by such means, and he then gave some figures bearing on this subject, and also mentioned the great difficulties that had to be overcome in the matter of ancient water rights.

Col. CUNNINGHAM pointed out another serious limitation than that mentioned in the paper. An essential point of the machine was that one part was under water while the other was above, and it was consequently limited to the case of moored barges. He quoted difficulties such as occur in India, where streams rise 40 feet, and in which cases boat bridges have to be entirely removed during big rains.

Mr. PEARSALL suggested, in reply, that efficiency might be much increased by putting the machine across the whole width of the stream where possible.

Prof. HELE SHAW responded to Col. Cunningham by suggesting that its very form, on account of its concave and convex surfaces, indicated that it might be submerged and not used on a barge.

Mr. WYLLIE alluded to the question of side pressure, to which the author, in reply, drew attention to the supports as shown in the diagram, to take this side pressure.

ELECTRIC LOCOMOTIVES: SOME RESULTS IN ACTUAL WORKING.

By ALEXANDER SIEMENS.

(*Read before Section G, August 5th.*)

THE object of the present communication is to place on record the performances of two electric locomotives, the most powerful of their kind, which were supplied at the end of last year by Messrs. Siemens Brothers & Company to the City and South London Electric Railway.

In the year 1888, the Company, then called the City of London and Southwark Subway, issued a specification asking among other things for electric locomotives capable of developing a maximum of 100 brake H.P. Owing to financial considerations, the contract was not placed with Messrs. Siemens Brothers & Co., although a perfect agreement had been arrived at on the technical points of the question.

The City and South London Company, however, invited Messrs. Siemens Brothers & Company again in the beginning of last year to tender for locomotives in accordance with a specification practically identical with that agreed upon in 1888; and as a result two electric locomotives have been built and are now working.

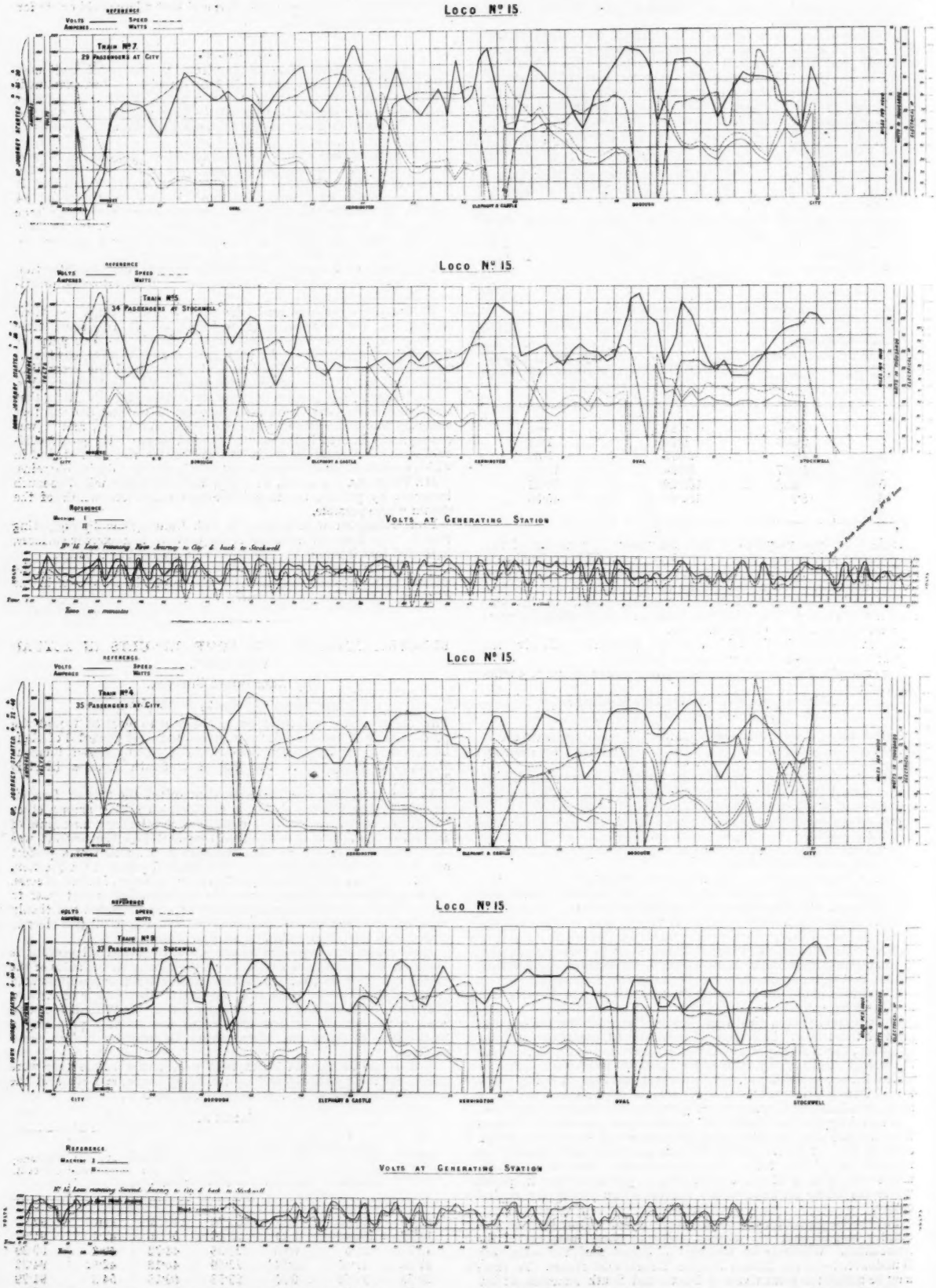
Each locomotive carries two motors, and the use of all gearing is obviated by winding the armatures of the motors on the axles of the wheels of the locomotive. This method of construction was illustrated by a model shown at work at a meeting of the Society of Arts on May 18th, 1881, and had been first suggested by Sir William Siemens, who, at the time of his lamented death, was actively preparing a proposition to work the Metropolitan Railway by electric locomotives.

The motors for the two locomotives were tested before they were fitted into their places by means of a Prony brake, and some of the results of this first set of tests are given in Table A.

TABLE A.

Speed in miles per hour.	Electrical H.P. put into motor armature.	Electrical H.P. put into motor magnets.	Total electrical H.P. per motor.	Total electrical H.P. per locomotive	Brake H.P. measured.	Efficiency per cent.
12·25	56·96	2·8	59·76	119·52	110	92
14·77	24·42	1·21	25·63	51·26	47·1	91·87
15·7	21·5	0·86	22·36	44·72	40·2	89·89
17·83	21·85	0·74	22·59	45·18	42·62	94·32
22·73	29·23	0·35	29·58	59·16	54·3	91·79
24·7	19·5	0·2	19·7	39·4	36·6	92·68
30·6	26·27	0·17	26·44	52·88	48·76	92·19

Since the two locomotives have been set to work on the railway they have had to keep the same time as the others, so that their full power cannot be utilised, but it has been found that their efficiency is satisfactory in every respect.



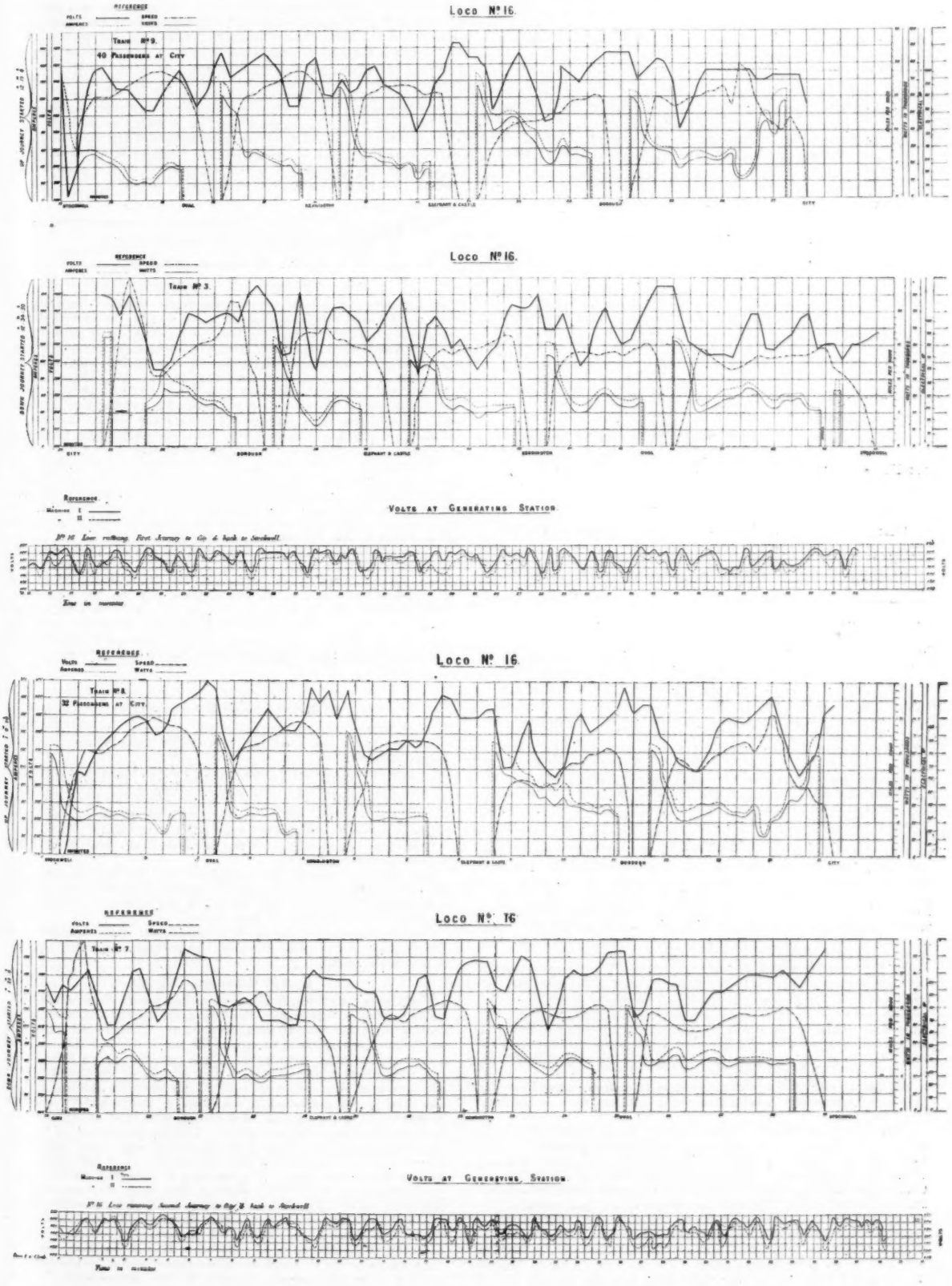
Observations of the current and electromotive force have recently been made simultaneously, by taking sets of readings on the ammeters and voltmeters, both at the generating station and on the locomotive. From these observations the curves accompanying these notes have been plotted. At the time these observations were made the locomotives had run about 8,000 statute miles, and on all four motors the brushes were wearing at the rate of about $\frac{1}{4}$th of an inch per 1,000 miles run; this small wear being a consequence of the motors running sparkless and practically without heating.

On examining the curves it will be noticed that there is no simi-

larity whatever between those representing the volts at the generating station and on the locomotives respectively; this is, however, easily explained by the consideration that the volts at the generating station are influenced by all the trains in motion at the same time, while the volts on each locomotive are principally influenced by the demand of the locomotive itself.

When the train is started, the current is regulated by the driver, so as not to exceed a certain amount, by means of switches inserting resistances into the main circuit, but these resistances are cut out within half a minute of starting, so that the waste of energy in the resistances is kept as low as possible.

Each locomotive, fully equipped, weighs 13½ tons, and the weight



of the train o. carriages it has to draw is about 21 tons. To this the weight of the passengers has to be added.

A summary of the results is given in Table B, which shows that the average power developed by each locomotive requires a current of not more than about 50 ampères, although in starting as much as 140 ampères are required.

TABLE B.

	Watt minutes.	Amp. minutes.	Total time including stops.	Mean volts.	Mean amps.	Average running speed. Miles per hour exclusive of stops.
Stockwell to City.			min sec			
Loco. No. 15. Journey 1	322,660	768·65	14 40	419·7	52·41	13·05
" " Journey 2	291,995	689·33	14 16	423·6	48·34	13·27
Loco. No. 16. Journey 1	317,640	733·32	14 40	433·2	50·00	13·29
" " Journey 2	315,660	751·32	14 50	420·15	50·60	13·41
Mean	311,988	735·65	14 36	424·16	50·33	13·25

	Watt minutes.	Ampère min.	Total time including stops.	Mean volts.	Mean amps.	Average running speed. Miles per hour, exclusive of stops.
City to Stockwell.			min sec			
Loco. No. 15. Journey 1	323,665	766·05	15 30	422·5	49·42	12·19
" " Journey 2	312,995	737·98	15 26	424·1	47·83	12·58
Loco. No. 16. Journey 1	305,320	717·99	15 8	425·2	47·46	13·21
" " Journey 2	321,660	749·31	14 56	429·25	50·19	12·83
Mean	315,910	742·83	15 15	425·26	48·72	12·7
Final Mean ...	313,949	739·24	14 55	424·71	49·52	12·97

This fact illustrates at the same time the peculiar difficulties which have to be grappled with in the construction of such locomotives, which have to work under conditions almost diametrically opposite to those of generating dynamos in electric supply central stations.

DISCUSSION.

Prof. UNWIN said he thought that at the present time there was hardly anything more important than the proper construction of electric locomotives.

Mr. GREATHEAD, having described the nature of the line, said the steepest gradient was 1 in 30, and that on a sharp curve it would be seen that it is an exceptionally heavy one for all kinds of traction, except perhaps cable, for which the line was originally constructed. There were now four engines at the generating station, but two were sufficient, and when the traffic was light, one would be sufficient; there was therefore a large margin to allow for extension of traffic when the line was carried, as it was intended to do, to Clapham. He mentioned that the average load per train throughout the year was fifty-one passengers. The Siemens locomotives had worked very satisfactorily and without stoppage from any cause. There were fourteen locomotives of the Mather & Platt make, and it was decided, after much anxious consideration to adopt gearless locomotives. He mentioned that the Siemens armatures, after much running, had been found quite cold, and no repairs whatever had been necessary.

Dr. SILVANUS THOMPSON said the motors used were probably but an intermediate type between the small ones of the past, and the large ones of the future. It would be found necessary to build electric locomotives with big, heavy and strong field magnets, and constructors must not be afraid of deadweight. It was a question of design and construction whether they could work the motors with field magnets giving strong enough intensity to the magnetic field to enable them to work with small currents.

Mr. TRAILL said he was still using Siemens motors on the Portrush line, which were made in 1883, and the generators now in use were of 8 tons.

Prof. G. FORBES wished to point out one or two causes of trouble in the past. Firstly, in the failures of the smaller armatures; these had been due almost entirely to heating and consequent breaking down of the insulation. In the case of the City and South London Company's line the change of design was to a great extent responsible for the heating effect. He said the success which had attended the working of the electric locomotives on the City and South London Railway was a sufficient answer to those who held up numerous accidents to armatures in the past, and pointed out that electric traction was still in an experimental stage. The manner in which Messrs. Siemens had overcome all the difficulties was the obvious one of making the motor large enough. The professor here showed how the position of the field magnets, as originally intended, had been changed, and how parts of the field magnets had been cut away to allow for this change. He, as having originally suggested carbon for brushes, protested against the wrong use of carbon brushes, and advocated the use, not of one carbon but of several, each with an independent spring. Referring to the tables, he called attention to the fact that all the trouble came in at the starting point, and not at the high speeds; it was at the lowest speeds that the greatest precaution had to be taken as to the working of the machine, and he asked for further information from the author.

Mr. ALEXANDER SIEMENS thanked the various speakers for their congratulations. He said in the generating station there were two machines, and there were also only two circuits. He was glad to know that Dr. Thompson considered that his company had made progress in electric locomotion. Respecting what Prof. Forbes had said, he thought a distinction must be made between those wound on the Gramme, and those on the drum principle. As to carbon brushes, he considered any kind of brush, whether of carbon, copper, or otherwise, if well made and used, there was no practical difference.

The PRESIDENT (Prof. Unwin) thought it was very generous of Mr. Siemens to give such good data for working as he had. He thought that the building of big armatures and big field magnets would eventually lead to the mechanical engineer being called upon to consider the question of the disaggregation of the axles of big motors. He then proposed the usual vote of thanks.

THE DESTRUCTION OF LIGHTNING PROTECTORS BY RECENT MUNICIPAL LEGISLATION.

By W. H. PREECE, F.R.S.

(*Read before Section G, August 8th*, 1892.)

THE immunity of private houses from being struck by lightning is very marked, and this is considered to be due to the fact that the lead on our roofs and the iron stack pipes that drain these roofs, connected as they are together, form admirable lightning protectors. Any charge of atmospheric electricity which may fall upon a house so protected is conveyed harmlessly away to the earth. Householders are now required to remove these pipes from direct connection with the drains, and to leave an air space between the end of the pipe and the grating of the drain. The result is that the electric conduction of the pipe is broken, the stack pipe ceases to be a lightning protector, and houses are left exposed to the dangers of atmospheric electricity.

The remedy is very simple. The pipe need not be entirely cut away; three-fourths of its circular section may be removed for the distance required, and one-fourth may be left to maintain the old electrical connection, or if the separation has been effected, then the stack pipe should be connected with the drain by a wire or rod, so as to restore a path for the charge to the earth.

Householders are also now compelled to put up stack pipes to ventilate their soil pipes, erecting above their roofs a metal tube forming a prominent object, exposed to the atmospheric charge and terminating frequently in an earthenware pipe on the first floor. They are thus liable to be struck by lightning without offering any means of escape. They should be connected electrically with the earth either directly or indirectly through the stack pipes, which would then make them sources of safety rather than of danger.

NOMENCLATURE OF UNITS.

PROF. LODGE prepared the following statement, which was submitted at the discussion on nomenclature of units in Section A, on August 9th, 1892:—

In view of the hoped-for presence of Prof. von Helmholtz and other distinguished foreigners at this year's meeting of the British Association in Edinburgh, it will probably be recognised as suitable to take up and continue the discussion on new electro-magnetic units for practical purposes, which was begun last year at Cardiff.

I therefore beg to contribute the following notes, and to conclude by moving some resolutions.

One great fact brought into prominence by the practical development of electricity is the analogy or reciprocity between the electric and the magnetic circuit, and this is the fact which it behoves us to emphasise in the naming of fresh units.

The magnetic circuit has as yet no authorised names applied to it. The electric circuit is well provided, but perhaps one or two improvements can be made.

(1.) THE ELECTRIC CIRCUIT.

The first point on which I consider that practical men would do well to insist is that names shall be given to the complete things dealt with, rather than to mere coefficients. Thus of all units with which they are concerned there can be no doubt but that *volt* and *ampère* are the most prominent. These are the active things with which electrical engineers have to deal, and these are the things for which meters exist on every wall in an electric lighting station. The ohm, or unit coefficient of resistance, is comparatively academic in character; it is a constant of a coil of wire or of an underground lead, it is nothing vivid and active. The engineering use of the term ohm is mainly in connection with insulation and other high resistances; for large conductors the equivalent "volt per ampère" is perhaps more often used. It is the drop of potential which a given conductor entails for a given current that is of real interest to an engineer, and it is this of which in large leads he consciously thinks.

A 6-ohm conductor means one that drops 6 volts for every ampère that is sent along it. If you send 3 ampères along such a line, the potential at the far end is 18 volts below that at the near end. The clear realisation of this fact would be almost aided by the complete title, 6 volts per ampère, instead of the abbreviation, 6 ohms. Nevertheless, the name ohm is in common use, and hence may be assumed useful.

A still more useful name, however, for good conductors would really be the reciprocal of an ohm—the ampère per volt. Suppose this called a mo, as Sir William Thomson once suggested, then a cable

of 20 mos would be one that conveyed 20 ampères with a drop of 1 volt. A thousand-mo cable would convey 500 ampères with a drop of half a volt, and so on. It is more directly practical to think of the ampères conveyed per drop of voltage, than of the drop of voltage per ampère. I believe that some authorised name for unit conductance would be welcomed.

Units of Inconvenient Size.

The authorised name "coulomb" for unit quantity is barely used by engineers, who are content with ampère-hour; thus proving that what is needed in practical units is not so much a consistent decimal system, as a set of units each of practicable magnitude.

Farad.

The effort after consistency has resulted in the useless "Farad;" and this should be a lesson not to try and fix units of unreasonable size. The C.G.S. units already exist as a consistent system; the only objection to them is that they are of unpractical size. The whole object of devising a practical system of units was to have things of every-day size to deal with. The volt, the ampère, and the ohm satisfy this condition. The coloumb, the farad, and the watt do not. Already they have practically given place to the ampère-hour, the microfarad, and the kilowatt.

Considerably more progress would have been made in knowledge of ordinary capacities if the microfarad had been called the farad, so that easy submultiples of it would have been available to express the capacity of Leyden jars, and such like things. The capacity of an ordinary jar would then have been a few millifarads, and a microfarad would have been the capacity of a short bit of connecting wire. I ask whether this change would introduce serious confusion even now? I think not. Nobody cares the least about "coulombs per volt," and so there is no sense or use in the present farad. Telegraphists would surely soon consent to drop the useless prefix micro; and the factor of a million is too great to render doubt possible as to what was intended, even in the transition stage. It ought to be regarded as essential to have the practical unit somewhere not hopelessly away from the middle of the range of probable multiples and submultiples.

Coulomb.

A coulomb again is almost useless as a synonym for the ampère-second; it is so easy to speak of ampère-minutes or ampère-hours. If the name coloumb could be set free from its present superfluous meaning, it could usefully be applied to the electrostatic unit of quantity, which wants a name. Teachers would find it convenient at once, and in the apparently imminent line of development engineers might find it useful before long. It is the charge on a two-centimetre sphere at a potential of 300 volts (or on a 1-foot sphere at 20 volts). The capacity of the two-centimetre sphere would be $\frac{9}{10}$ths of a (new) microfarad.

Watt.

Lastly with regard to the watt. The name volt-ampère is almost as good as the name watt, especially since the watt is also one joule per second.

Both names, watt and joule, are not really wanted by electricians, to whom their coexistence is rather confusing. I believe it would be more convenient to use the term watt in the sense it gets so frequently used now, viz., energy, say a volt-ampère hour; in which case a kilowatt would be synonomous with the present Board of Trade unit.

The rate of working, or power, could then be expressed in a rational and unforced way as so many watts per hour or so many volt-ampères. It is much more natural to give a name to a definite thing like a quantity of energy, than it is to give it to a mere rate of working. The latter is instinctively felt to need a reference to time; just as a velocity unit has not been practically found to need a name, being quite simply expressible in feet per second or miles per hour; and even when a name has been given, like "knot," instinct constrains people to practically get rid of it again by speaking of knots per hour, just as we find "kilowatts per hour" already often used in electrical workshops. I suggest, therefore, that the present watt is too small, that it is sufficiently expressed by a joule per second, and that it would be more useful if magnified 3,600 times, and turned into a unit of energy.

That we should thus have several energy units—the erg, the joule, and the watt, all of quite different sizes, is no objection, but an advantage, seeing the extreme importance of energy. Such things as length, mass, time and energy demand a fair range of units. It would be tedious to express centuries in seconds.

(2.) MAGNETIC CIRCUIT.

In speaking of the magnetic circuit I wish to refer back to my opening remarks concerning the electric circuit, and the class of things for which names should be found. In the magnetic circuit the only thing at present seriously attempted to be named is, in accordance with the historic parallel of the ohm, a coefficient or characteristic of a coil of wire—its coefficient of self-induction; the unit of which has been called variously a secohm, a quadrant, and a henry.

Total Induction.

But the real active thing with which engineers are concerned is total magnetic induction, total number of lines of force across an air gap; as between the pole pieces or through the armature of a dynamo, or in the circuit of a transformer. It may be called the electromagnetic momentum per turn of wire; or the surface integral of B. This total induction is in some respects analogous to electric current, and has occasionally been called magnetic current (a bad name), or "magnetic flux." It is, however, more strictly analogous to the coulomb, and its time rate of variation is the more proper representative of electric current.

Its common practical name at present is "total lines," or "total induction," or "number of lines."

Now, "one line" is awkward as a unit, besides being (if a C.G.S. line) inconveniently small. The earth, for instance, sends 4,400 such lines through every horizontal square metre about England; through a square inch it only sends a fraction of a line. A practically sized unit of induction badly wants a name, and "henry" would have done for it very well, and have been both more suitable and more useful for the actual quantity than for a coefficient. But "henry" has already been half appropriated to the secohm, so, for illustrative purposes at any rate, I propose to use the name "weber" for the unit magnetic flux.

Concerning the most convenient size for the weber, there is much to be said for making it 10^8 C.G.S. lines, though that is bigger than ordinarily occurs in practice; because then a wire which cuts one weber per second will have a volt difference of potential between its ends. Or a coil of 20 turns through which the magnetic induction changes at the rate of one weber per second will have an E.M.F. of 20 volts induced in it. The average E.M.F. in such a coil, spinning 30 turns a second, and enclosing a maximum total induction of one weber, is 600 volts.

This is the dynamo use of the unit; the following is the motor use:—

A wire carrying an ampère and cutting a weber per second, does work at unit rate, viz., one joule per second.

Probably the simplicity of all this compensates for the rather unwieldy size of the unit. A strongly magnetised piece of iron may have 20,000 lines to the square centimetre; so a weber could occur across a narrow air-gap half a square metre in area.

The earth gives an induction of about one weber through every 23,000 square metres of England, or 100 webers per square mile. The earth induction through a horizontal square metre is 44 microwebers, so with micro- and milli-webers the range would be fairly covered; though a smaller weber would have been better if it had been equally convenient as regards the volt.

The pull between two parallel surfaces joined by a weber is $\frac{10^{16}}{8\pi}$ dynes, or four hundred thousand tons. A milli-weber gives less than half a ton pull, and a micro-weber less than half a gramme.

Because of the property that the voltage excited in a circuit is equal to the webers cut by it per second, a weber might be called a sec-volt. It is equal to a secohm-ampère-turn; that is to say, if a single turn of wire can have a self-induction coefficient of one secohm, it will excite a weber of induction for every ampère passing through it.

[Such a circuit, in the form of an anchor ring, would be enormous, something like a mile across; but it could be made in the form of a solid cylinder of best iron ($\mu = 2{,}500$), with an axial perforation for the wire, and 80 metres long.

If a secohm coil has n turns, then an ampère passing through it excites only $\frac{1}{n}$th of a weber; for, since every turn encloses the induction, the latter is effective n times over, and so the induction coefficient is n times the induction per ampere, or n^2 times the induction per ampère turn.]

No name is needed for intensity (or density) of induction (B), for that can always be expressed in webers per unit area.

[For instance, strongly magnetised iron, with, say, 10,000 lines to the square centimetre, has one-tenth of a weber per square foot, or 0·7 milli-webers per square inch.]

And there is a practical gain in thus leaving the specification of area open, for it enables British units of length to be employed in measuring air-gaps, yokes, cores, and pole-pieces.

So long as dynamo dimensions are commonly expressed in inches, there is no serious objection to specifying induction in fractions of a weber per square inch or per square foot.

Magneto-motive Force.

Now consider the magnetic analogue of the volt; the unit of magnetic potential or magneto-motive force. By this is understood the line integral of the magnetising force, H, the quantity $4\pi nC$, the step of potential once through and all round the circuit of a coil. It is a quantity most important in practice, and requires a name.

Mr. Heaviside has suggested the name "gaussage," as analogous to voltage; and if this were adopted, the unit of magneto-motive force would be the gauss. The intensity of magnetising force would be the gauss-gradient, or drop of gaussage per centimetre; no special name is needed for the unit of this quantity, H.

The common practical unit of gaussage at present is the ampère-turn, and this has several advantages. It may, however, be found better to make some convenient number of ampère-turns into a gauss; for instance, the C.G.S. unit of gaussage would be $\frac{4\pi}{10}$ or 1·2566 ampère-turns. If that were adopted as the gauss, the horizontal component of the earth's magnetic intensity about here would be, say ·18 gauss per linear centimetre.

But this unit, whether the C.G.S. unit or the ampère-turn, is very small. The step of potential all round a single ampère-turn is only equivalent to a vertical step of about 2 centimetres in the earth's field.

Nevertheless, in spite of its smallness, the ampère-turn as practical unit of gaussage will probably commend itself by reason of its simplicity. Let us see how it works out.

Reluctance.

The ratio of gaussage to the induction excited by it, is a quantity characteristic of the magnetic circuit, and called its reluctance or magnetic resistance. This is the quantity $\frac{l}{A\mu}$ for simple circuits, or

$\Sigma \frac{l}{A \mu}$ for complex ones; it is unfortunately not constant for any but air circuits. This constitutes one difficulty of naming its unit satisfactorily, else it might be expressed as so many "gilberts" or "sturgeons" (analogous to ohms). It is, however, fairly constant under many common conditions of practice, and it can always be expressed as gausses per weber; and perhaps this way is sufficient.

A magnetic circuit with unit reluctance is one that requires one gauss to induce in it one weber.

Permeability.

Permeability (μ), analogous to electric conductivity, would be measured by the webers induced through unit cube of the material between whose faces there is unit fall of gaussage. It has been suggested (by Prof. Perry) that the permeability of air had better be called $4\pi \times 10^{-9}$. But the whole electro-magnetic system of units is based on the μ for air being called 1; so it would be rather confusing to change that. Moreover, it would be a retrograde step to affix another incorrect value to the constant μ, instead of waiting and trying to find out what its value really is. It is better to adhere for the present to the existing table of permeabilities, and to use whatever constant factor may be needed in order to turn $\frac{l}{\mu A}$ into practical units of reluctance.

Permeance.

But the reciprocal of reluctance, or the webers induced per gauss, may be the more instructive thing to attend to and name; just as conductivity is often more directly interesting than resistance. This reciprocal ratio, $\frac{\mu A}{l}$, has been called "permeance," and that is not a bad name for it; it is proportional to the inductance of a single-looped circuit. Permeability is the permeance of unit cube of the material. Permeance is the webers induced per unit drop of gaussage. Permeability is the webers per unit area induced by unit gauss gradient.

The permeance of the magnetic circuit enclosed by a solenoid of wire is the same as its appropriate self-induction-coefficient divided by 4π times the square of its number of turns.

The C.G.S. unit of permeance (or of reluctance) is that of a centimetre cube of air, and is not a bad-sized unit. But it is inconsistent with the weber as 10^8 and the gauss as a single ampère turn.

One of the three must give way.

On the whole, I have no hesitation in suggesting that the derived unit (that of permeance) must give way, and be taken as $4\pi \times 10^7$ C.G.S. units, in order to harmonise with the other two as already defined.

The fact is that the great size of the weber renders a small gauss desirable, in order that their product may not represent too large a quantity of energy. For instance, if 1 C.G.S unit were taken as the unit of permeance, the weber being fixed at 10^8, then the gauss would also be 10^8, and the gauss-weber would be 10^9 joules, or nearly 300 Board of Trade units, which is far too much.

Whereas, if the unit of permeance is fixed high, and the gauss kept small, then the energy corresponding to a gauss-weber may be moderate. Thus with 10^8 C.G.S. as weber, and an ampère-turn as gauss, their product is only $\frac{10^9}{4\pi}$ ergs, or $\frac{100}{4\pi}$ or about 8 joules; which will be useful in energy considerations connected with the heating of transformers.

I therefore propose, in order to retain the ampère-turn as unit of gaussage, that the permeance of a cylinder of material of length l and area A be reckoned as $\frac{\mu A}{l}$ multiplied by $4\pi \times 10^7$, if dimensions of the cylinder are measured in centimetres; μ being its ordinarily tabulated value with air = 1. If dimensions are measured in inches, then the permeance of a cylinder will be $\frac{\mu A}{l}$ multiplied by $\frac{4\pi}{2{\cdot}54} \times 10^7$, that is, by about $\frac{1}{2} 10^8$.

The unit of permeance thus suggested is immensely big, and it requires a name of which easy sub-multiples could be formed.

A slab of iron 1 centimetre thick, and with its $\mu = 2{,}500$, would need an area of 5 square metres in order to have unit permeance; but a micro-unit would be possessed by an air-gap a millimetre thick and less than a decimetre square.

PROPOSED RESOLUTIONS.

(1) That the unnecessary prefix "micro" be dropped before the word farad, and that the farad be defined afresh as 10^{-15} C.G.S. electro-magnetic units of capacity.

(2) That the name "mo" for the unit of conductance or the ampère per volt, be recognised and adopted. (Every *mo* in a cable enables it to carry an ampère with a drop of 1 volt.)

(3) That the ampère-hour be recognised as a convenient practical unit of electrical quantity.

(4) That the volt-ampère-hour be recognised as a convenient practical unit of electrical energy, and be called the watt. (It equals 2,640 foot-pounds, or a trifle over a foot-ton.)

(5) That the present Board of Trade unit be called a kilowatt.

(6) That the ordinary unit of power be a kilowatt per hour. [It equals about four-thirds of a horse-power, more accurately $\frac{1{,}000}{746}$ H.P.]

(7) That it is convenient to retain the name joule in its present sense of a volt-coulomb, or 10 million ergs, for use in the science of heat; since heat-capacities are conveniently expressed in joules per degree; and it will be handy to remember that a volt-ampère generates one joule of heat per second.

(8) That the name coulomb be affixed to the electrostatic unit of quantity [for academic purposes].

(9) That a name be given to unit magnetic flux or total induction, and that the name weber is suitable.

(10) That the most convenient size for the weber is 10^8 C.G.S. units or "lines" (since the rate of change of this through a circuit is equal to the induced voltage).

(11) That a name be given to unit magnetic potential or magneto-motive force, and that the name gauss is suitable.

(12) That the handiest size for the gauss is one ampère-turn.

(13) That a name be given to the ratio of the weber to the gauss, or unit of permeance, or self-induction per turn of wire. [If the above resolutions were adopted, this unit would be $4\pi \times 10^7$ C.G.S. units, or $\frac{1}{4}$ secohm per turn.]

(14) That intensities of field be expressed in gausses per unit length, and densities of induction in webers per unit area (leaving the length or area unit open for practical convenience to arrange).

No doubt many of these recommendations have been made before. Mr. Preece has often urged the change of farad, so that I hope there will be no difficulty about that.

I find that my magnetic suggestions are very similar to those suggested by Prof. Perry in his modified letter to the Committee as published in the *Electrician*, Vol. xxvii., p. 355 [July 31st, 1891], and received there with approving editorial comments. The accordance between our suggestions is satisfactory, and makes it likely that they are such as engineers may be satisfied with and be willing to adopt. I need hardly say that I lay no stress upon the particular *names* here proposed. In choosing them I have been influenced by such trivial considerations as the selection of a monosyllable to correspond with volt, and a dissyllable to correspond with ampère or coulomb.

[With regard to Prof. Perry's footnote concerning college instruction and use of C.G.S. units, I suppose systems of teaching differ, but a senior student *ought* to be taught to deal with concrete quantities in so familiar a manner, that no possible admixture of units can be any puzzle to him, nor involve anything worse than a little tiresome arithmetic.]

MECHANICAL UNITS.

There are several quantities in dynamics beside the joule and the watt, for which brief names would be advantageous. I do not propose to discuss these fully now, but the present opportunity might be utilised by agreeing to at least one unit, that of pressure, viz., the "atmosphere," which might be defined as 10^6 C.G.S., or dynes per square centimetre, and stated to be equal to the pressure of a column of mercury 75 centimetres high at a specified temperature. The inconvenient pressure, 76 centims., might be spoken of as a Regnault atmosphere. I believe that a smaller unit of pressure, for instance, the micro-atmosphere or "barad," might also be usefully named. These pressure units will be useful for expressing energies per unit volume also, and the "barad," or whatever other name is decided on for the erg per cubic centimetre, is of reasonable magnitude for many purposes.

(To be continued.)

ANTI-FRICTION MATERIALS FOR BEARINGS USED WITHOUT LUBRICANTS.

By KILLINGWORTH HEDGES, M. Inst. C.E.

(Read before Section G, August 8th.)

THE use of oil as a lubricant in machines is to separate the rubbing parts and to diminish the friction of metal upon metal by an intervening film of the lubricant.

If the oil is supplied in sufficient quantity to cause the entire separation of the metals, the friction may be reduced to a measure of the viscidity of the unguent used; where oil is furnished in less quantity, then the friction of metal upon metal is usually resistance due to interlocking particles of the revolving and stationary parts, the oil used under this condition finding its way from the bearing loaded with the metal that is gradually torn from either the revolving shaft or the bearing in which it has worked. It is a well-known fact that heavy lubricants effect a better separation of the metals than those that are more limpid, although the power required to slide the surfaces one upon the other is much less with the latter than with the former, but at the same time the wear and tear of the metal may be greater. It has been stated by more than one authority that it makes little difference what metal is used for the journal of a revolving shaft provided oil in sufficient quantity can be introduced, so as to separate the shaft from the bearing in which it revolves; this is proved by the success which attends the use of cast iron for the bearings of ordinary shafting, it being no unusual occurrence to find the cast iron sleeve of an adjustable hanger showing the tool marks after running several years with an excess of lubrication. Such a bearing would, however, quickly seize if the oiling was neglected, and therefore the friction may be said to vary according to the attention paid to the oiling. For very low pressures, amounting to only a few pounds on the square inch on the rubbing surfaces, oil causes a loss of power, so as to make it advisable wherever possible to dispense with it altogether; Prof. Coleman Sellars even goes further than this and states that even when the pressure on the rubbing surfaces is less than 50 lbs. per square inch, the viscidity of the unguent acts as a sensible retardent.

Engineers have for a long time been looking for a material capable of being used for bearing surfaces, and having a low co-efficient of

friction when worked dry and without any oil. The idea is not one of recent date only, but may be said to go back to the time of the Romans, as some of the hand flour-mills found at Pompeii have the lower stone fitted with an iron bearing which evidently worked dry in the stone socket of the upper stone. The celebrated Coulomb experimented with an iron axle moving in a bush of elm, the friction was stated to be "$\frac{1}{10}$th of the force of pressure;" he also made numerous experiments with wood axles slightly smeared with tallow, and also recommended the use of blacklead; the material he found to give the best results was green oak on elm, and I believe the wooden axles of the waggons which are used in Derbyshire at the present time to transport the heavy grindstones from the quarries, are constructed with axles of oak in a similar manner; throughout Egypt, in the Nubian water wheels, which are everywhere employed for irrigation, unlubricated wooden bearings are used, which appear to wear very slowly, the surface of the bearing acquiring a fine glaze. Stone bearings have also been employed for shafts; according to Rankine the natural stones fit for this purpose are those which are wholly free from grittiness, and are somewhat inferior in hardness to iron, such as gypsum, pure clay slate, compact limestone, marble, and silicate of magnesia; from the latter the substance called "adamas" was made by calcining the magnesia, grinding and moulding it by hydraulic pressure into blocks which were then baked.

In addition to these oilless bearings there are others in which perhaps a small quantity of grease might have been employed, such as the leather bushes used in spinning wheels, and the leather band may be quoted as an instance of leather working on wood on that part of the oar which works in the rowlock. Glass has also been tried, but the only kind which has survived to the present and has been the most successful of all is the plumbago bearing. The author has been told by the old millwrights that this material was often used as the footstep bearing of the upright shafts in water mills, and most of us have seen plumbago employed instead of tallow for lubricating wooden bearings and there is the familiar example of the carpenter's screw. The first adaptation of plumbago in a more practical form was the invention of Gordon, who inserted a number of moulded plumbago plugs in the standard size axle box of an ordinary carriage wheel; it is said that the vehicles ran successfully without any lubricant.

Graphite or plumbago is the principal ingredient in numerous inventions for dry bearings, many of which have not got further than the Patent Office; it has been mixed with pulverised iron, asbestos, vegetable fibre, paper pulp, blood, and in one curious adaptation sponge is used; in nearly all these applications the anti-friction composition is packed into suitable grooves, which are used in the bearing, very much in the same way as asbestos is used in cocks. A substance which has been termed "metalline," which, although it contains graphite, appears to be composed of finely divided lead, has been rather extensively employed; the chief disadvantages were the expense due to the way the material was used in the form of little plugs let into drilled holes, and the necessity for oiling when the plugs were worn sufficiently to cause contact between the metallic surfaces, thereby changing the character of the bearing.

The latest form of dry bearing is of solid material, which can either be moulded so as to fit any plummer block, or can be tooled or worked in the same manner as an ordinary brass. A new material for this kind of bearing has been recently tried in the United States, it is termed fibre graphite, and consists of finely ground plumbago, mixed with wood fibre in a moist condition, and pressed into a mould of proper form; it is then saturated with some drying oil, and oxidised in hot dry air. This bearing has been favourably reported on by the Committee of the Franklin Institute, and a shop has been fitted up complete, so that the whole of the machinery, including the steam engine, runs without any lubrication at all. The report, which may be taken to apply to dry bearings generally, states "that an invention of this kind by diminishing the use of lubricants, diminishes the cost of machine construction, by doing away with the many devices incident to oil—oil cups, oil-hole covers, the oil-holes themselves which have to be carefully placed, oil tubes to lead the lubricants to the inaccessible parts of machinery, as well as the cost of the personal attention and the cost of the lubricant required to keep the machinery in perfect order."

My own investigations of a suitable material for an oilless bearing began with the use of plumbago, which was moulded so as to form a circular bush, but this was soon discovered to be a failure on account of its rapid wear. I then constructed bearings of ordinary carbon, such as is used in batteries, and for producing the electric light by means of the voltaic arc. The first experiment was made with the bearings of a small dynamo, which ran for a considerable time, but the drawback of using carbon was mainly on account of the impurities which it often contained; a small amount of silica in the carbon was found to cut the shaft very badly, whilst if soft carbon was used the wear was as rapid as with plumbago. In order to lessen the cutting action and the friction, finely powdered steatite was mixed with the carbon, and henceforth no difficulty was experienced, even when the load was unequally distributed on the bearing. The name of carboid has been given to this mixture, its specific gravity being 1·66, that of carbon, as used in arc lamps, being about 1·68; therefore carboid is about one-fifth the weight of brass, it can be moulded with the same ease as carbon, and can be turned, bored, or shaped to any desired form; in practice it is found that the cylinders, as they leave the dies, are quite true enough to be put into bearings without any tooling, although it is preferable to run for a short time with half the load, and then remove and scrape the bearing so as to equalise the surface of contact.

Friction as compared with lubricated bearings.

Prof. Sellars, writing on the Franklin Institute report, states that "the co-efficient of friction is lower with the dry bearings experimented on than that of many oiled bearings in good condition, and that it is undoubtedly lower than with metal bearings, as usually operated with moderate attention and poor qualities of oil. It seems to be constant in its frictional resistance, whether warm or cold, while it does not run lighter when worn by use as some oiled bearings do. Its uniform action is better than many oiled bearings and very much safer; the constant amount of frictional resistance being known can be provided for in the power of the machine."

The above agrees in the main with Prof. Unwin's experimental results with carboid. A bearing, 1½ inches diameter by 2½ inches long, cut in halves, was recently tested under loads varying from 100 to 1,800 lbs. or about 15 to 170 lbs. on the square inch, at speeds from 110 to 490 revolutions per minute, the period of test extending over six days, during which it was kept almost constantly running without any lubrication or attention.

Summarising the experiments, it appears: 1st. That the coefficient of friction is almost the same, and has not diminished as the carboid became worn to a better bearing surface. 2nd. That the coefficient of friction increased as the temperature increased during the run, but is practically the same for any increase of pressure, and diminished with increase of speed, the maximum number of revolutions per minute being 490. 3rd. That no injury is caused to the shaft even if the bearing gets very hot, as it was found to be impossible to make it seize.

The trials were made in one of Prof. R. H. Smith's new design of testing machine, in which there is no bending pressure upon the journal at all, the load being adjusted by the compression of a spiral spring which presses upon both halves of the bearing with equal force. The heat generated by this form of machine is twice as much as that in which the load is applied to one step only, and this to a certain extent limited the pressure to which the bearing was subjected, and the experiments with greater pressures will have to be completed with another design of holder, so arranged that the heat generated has a better means of escape.

The conclusion arrived at by the author with regard to dry bearings is that the frictional resistance is governed by the conductivity of the shaft and the holder or support of the bearing; if this is arranged so that any heat generated is dispersed, the coefficient of friction will not exceed that of a lubricated bearing.

First costs.—If the bearing works under such conditions that any heat generated at starting a new bearing may readily be conducted away, the first cost of a dry bearing will be less than any form of brass, but taking the case of a dynamo bearing where any excess heat might be disadvantageous, it will be necessary to carefully true the bearing by scraping so as to fit the shaft, and under certain conditions where there is a great pull on the belt, it may be necessary to keep the bearing cool by means of a circulating flow of water.

Economy of Working.—This is very marked; besides the cost of the lubricants used in large establishments, there is also the attention required to apply the oil and keep the parts clean. In laundries and in other trades where unskilled labour is employed, the danger of oiling machinery in motion is very great; besides this there are instances where the lubricant used is in itself a source of danger, such as the risk of oil waste taking fire by spontaneous combustion, and the drip from bearings certainly renders the floors of mills highly inflammable.

Mr. C. J. H. Woodbury, C.E., of Boston, U.S.A., says "the losses by friction and spontaneous combustion of oils exceed those from any other cause." The carboid material is not affected by acids or alkalies, and can be run under water, it is inferior to carbon as a conductor of electricity, and by increasing the amount of steatite an artificial resistance can be formed in which the R. is double that of carbon rods of similar diameter; on the other hand, if a small proportion of steatite is added, it is extremely suitable for the collecting brushes of dynamos, as the commutator is lubricated without the use of any grease or oil, and the grade of the carbon kept uniform; the slight increase of resistance is unimportant, as in nearly all cases carbon brushes are copper plated.

The principal application of carboid up to the present time has been for the bearings of ordinary shafting, and for bushing loose pulleys; it has also been applied for the bearings of steam heated rolls such as are used in cloth mills and paper works. The result of two years experience and many experiments with light trucks seems to point out the desirability of extending its use to the axle-boxes of tramcars, and perhaps railways generally, as it involves no change in the axle boxes; even the existing brass can remain and be faced with carboid, which material can be cemented to either a smooth or rough surface.

Exhibits by the Carboid Oilless Gearing Company, of 7, Carteret Street, Westminster.

The bearing used in Professor Unwin's experiments after six days' running.

Carboid blocks similar to those which have been used for the wire-rope tramways in Edinburgh for last four months.

2-inch carboid bush taken from shaft after a year's constant use.

Tram-car axle bearing, coated with carboid.

Carboid dynamo brush, as used by the Electrical Construction Company.

DISCUSSION.

Prof. FORBES in the course of some remarks, said the author had spoken about the advantages of fibre graphite bearings, which had been so extensively experimented upon and used in America, as if they were perfectly similar to his own material. The cable tramway company in Philadelphia had long ago come to the conclusion that it was necessary to introduce in the plumbago, fibre. This substance was very different to that shown by Mr. Hedges. Personally, he thought the absence of a fibrous material was a disadvantage.

D

After a few remarks from a MEMBER, and Mr. HEAD,

The CHAIRMAN said he had carried out tests on Mr. Hedges's material, and found there was very little wearing. He did not think it would be possible to have a solid bearing without lubrication, which would have as low a coefficient of friction as a well lubricated bearing, but there were a great many cases where one might put up with the higher coefficient for the sake of convenience.

THE HUMAN BODY AS A CONDUCTOR OF ELECTRICITY.

By H. NEWMAN LAWRENCE, M.I.E.E.

(Taken as read in Section D, August 9th).

THAT the human body is no ordinary conductor has been long acknowledged, but the peculiarity of its conductivity and the conditions under which this conductivity varies, are subjects which have hardly yet been satisfactorily investigated.

In a former communication which I had the honour of putting before the Association,* I set forth certain observations on the resistance of the body to different forms of current. Since then other observers have published results of their investigations in the same direction, and a reasonable approach to the solution of the problem of body resistance has been made.

In the present communication I desire to take up that portion of the subject which deals with the conductivity of the body rather than with its initial resistance. To see what is the effect of a passage of current after the first resistance has been overcome and to find what are the differences of conductivity in the several parts.

The value of a true knowledge of the conductivity is of scarcely less importance in connection with accidental contacts with light and power circuits than that of initial resistance itself. It may easily happen that by the continued passage of current for a short time, the conductivity may be so improved that a voltage which at first was practically harmless, becomes ample to pass current enough to be fatal.

The experiments herein described were designed to show, first, the effect upon conductivity of the passage of a steady current for a few minutes, and second, to indicate the relative conductivity of different parts of the body after such currents had passed. Before going further, it may be well to glance at the position of affairs regarding the resistance of the body as a whole. Numerous investigators have given the matter their attention, notably Erb,† Lant Carpenter,‡ and Stone,§ and a gradual evolution of the truth has resulted, till to-day we find ourselves, not, indeed, at the complete solution of the problem, but in a fair way to arrive at it. We find that the resistance of the living body is by no means a fixed quantity, at any rate when the skin is included in the circuit. That it may vary from half a million ohms with small contacts and dry skin to 540 ohms with very large contacts and soaked skin, as shown by Dr. Hedley in his recently published book.‖ That its value between extremes depends upon the contact area and the degree of moisture, as shown by Dr. Harries¶ and myself. That the situation of the contacts in relation to the number of sweat glands covered has considerable influence, as demonstrated by Erb.† Further, that this resistance is much greater to continuous currents than to alternating currents, as found by Dr. Stone,‡ who gives the proportion as 2 to 1, and by Dr. Harries and myself,¶ who give the minimum proportion as 1·5 to 1.

Some investigators have concluded or assumed that the whole of the body resistance resides practically in the skin. Erb seems to be of this opinion, for in his work already referred to he speaks throughout of the "resistance of the skin." Jolly says, "the resistance of two layers of cuticle is equivalent to about 300 times that of the remaining tissues when a current is transmitted from one hand to the other."† The extent to which this may be true is yet unproved, I think, though there can be little doubt that a large portion of the whole resistance does reside in the skin when unmoistened.

Various attempts have been made to eliminate the skin resistance altogether, and so arrive at that of the tissues only. Carpenter, by means of soakage in salt and water for 60 minutes, arrived at a point beyond which the total resistance would not be reduced. Stone, by similar methods, claimed to have found the true body resistance; but in both cases the conclusion seems to have been more assumed than proved.

Waller, in his recent valuable work on Physiology,** gives the resistance of the skin as from 1,000 to 100,000 ohms, according to moisture, but does not accompany the statement with any particulars of how the figures were arrived at. Does he mean one or two layers of cuticle? Was the skin cut out, or in any way separated from the body? What was the contact area? Did he intend his figures to refer to the whole body resistance, on the ground that the portion due to substances other than the skin is so small, as to be negligible? The absence of these and similar particulars is much to be regretted, and without them one hesitates to use the figures as a basis for other calculations, even though coming from so eminent an authority on matters physiological. My own observation goes to show that not only the skin resistance, but that of "two layers of cuticle, plus the remaining tissues included," may be brought below 1,000 ohms, sometimes with continuous current, and frequently with alternating current. As already stated, Dr. Hedley has found the resistance of the whole body, including the skin, may be reduced to 540 ohms; while in a recent electrocution (MacElvain), the body resistance to alternating currents proved to be as low as 516 ohms from hand to hand, and 214 ohms from head to calf.*

The conditions under which Dr. Hedley arrives at 540 ohms as the resistance of the whole body, justifies us in regarding that as the minimum under most favourable circumstances, *i.e.*, in a bath when low E.M.F. is used; but we are still left in the dark as to how much, if any, of the resistance so obtained belonged to the skin only.

I have sought to get over this difficulty in a different manner. By inserting two internal electrodes of fairly large area, one in the mouth and the other in the lower part of the body, after passing the current for one minute, I found the resistance to be 534 ohms. Then while the lower electrode remained *in situ*, one of the non-polarisable electrodes described below was substituted for the mouth electrode, and placed upon the cheek outside the mouth. After again passing a current for one minute, the resistance was 1,468 ohms. The difference between these two resistances, viz., 934 ohms, may, I think, be fairly taken to represent the resistance of the skin under *one* electrode, and, this doubled, gives 1,868 *ohms as the resistance* of *two layers of skin* as in ordinary contacts. This conclusion, however, is only good for skin on the cheek or similar skin, with a circular contact of 2 inches diameter to each electrode. Skin in other parts of the body may have a greater number of sweat or other glands in such contact area, or it may have fewer, and, this, as shown by Erb,† causes proportional variations in resistance independent of other conditions.

The observations recorded below were all taken upon one subject. Two other subjects were tested, and the readings so obtained, while differing somewhat in value, bore out in the main the proportions shown by the first.

Special non-polarisable electrodes were used. They consisted of glass cups, having each a side orifice, 2 inches in diameter, covered with a piece of thin bladder. Each cup was filled with a strong solution of zinc sulphate, into which a zinc rod dipped, the other end of the rod passed through a rubber stopper in the neck of cup, and formed the terminal to which the battery wire was connected. These electrodes were warmed up to 95° F., by immersing the glass body of the cup in warm water till ready for use. When warm, the resistance of the two was 14·5 ohms. When in use the bladder covered orifice was placed upon the skin. An excellent contact, having only a thin membrane between the skin and a strong saline solution was thus obtained, and it was hoped that complications arising from dry skin, imperfect contact, difference of temperature and surface polarisation, were thereby eliminated.

An ordinary Leclanché battery of 14 cells, giving an E.M.F. of 15 volts, a switch, a current reverser, and one of Edelman's suspension milliampère meters, completed the apparatus used.

TABLE A.—*Conductivity readings. Continuous current. E.M.F. 15 volts. Direction longitudinal.*

Position of electrodes.	Current in milliampères at					
	Time 0.	1 min.	2 min.	3 min.	4 min.	5 min.
Arm—						
Hand (palm) and shoulder ...	0·63	0·96	1·08	1·21	1·22	1·22
„ and elbow (inside) ...	0·55	1·1	1·4	1·5	1·5	1·5
Elbow and shoulder	1·0	3·0	4·0	4·5	5·0	5·3
Leg—						
Foot (sole) and hip	1·0	1·5	1·8	2·0	2·2	2·4
„ „ knee (inside) ...	0·75	1·1	1·4	1·5	1·5	1·6
Knee (inside) and hip	1·5	3·4	4·1	4·5	4·8	5·1
Trunk—						
Neck and perinæum	3·5	6·0	7·1	7·4	7·1	7·4
Breast and „	1·0	2·5	2·9	3·5	3·8	3·9
„ „ right hand (palm) ...	1·0	0·8	0·76	0·75	0·77	0·77
„ „ left hand	0·6	0·55	0·54	0·56	0·56	0·53
Right hand and left hand ...	0 2	0·25	0·25	0·25	0·25	0·25
„ foot (sole) and abdomen ...	0·3	0·6	0·6	0·55	0·5	0·5
Left „ „ „ ...	0·9	0·75	0·66	0 6	0·56	0·55
Right foot and left foot	0·3	0·35	0·35	0·34	0·34	0·32

TABLE B.—*Direction transverse—other conditions as in Table A.*

	Time 0.	1 min.	2 min.	3 min.	4 min.	5 min.
Arm—						
Through hand (back and front)	0·85	0·75	0·68	0·68	0·69	0·7
Through fore arm „	2·0	4·5	5·7	5·8	5·4	5·0
„ upper arm „	2·0	5·0	5·5	5·6	5·7	5·8
Leg—						
Through foot (sole and instep)	0·25	0·4	0·35	0·32	0·31	0·31
„ calf (back and front)	0·25	0·9	1·9	2·6	3·0	3·5
„ thigh „ „	0·5	1·5	2·1	2·5	3·0	3·2
Trunk—						
Through chest (back and front)	1·02	2·4	2·8	3·2	3·3	3·5
„ abdomen „ „	0·2	0·7	1·4	2·0	2·5	2·7
„ chest (side to side) ...	0·15	0·42	0·9	1·15	1·4	1·6

* Leeds meeting, 1890, "Alternating *versus* Continuous Current in Relation to the Human Body," by H. Newman Lawrence and Dr. A. Harries.

† "Electro-therapeutics," by Wilhelm Erb, M.D.

‡ *Health*, October 5th, 1883.

§ Lumlian Lectures before Royal College of Physicians, April, 1886.

‖ "Hydro-electric Methods in Medicine," by W. S. Hedley, M.D.

¶ *Journal of Society of Arts*, March 13th, 1891.

** "Human Physiology," by Augustus Waller, M.D.

* New York *Medical Journal*, May 7th, 1892.

† "Electro-therapeutics," by Wilhelm Erb, M.D.

The first thing one notices in these tables is the difference in conducting power of the several parts of the body, and in order to make this point more clear I give in Table C. a list of comparisons based upon the figures found at the end of each five minute period.

TABLE C.

Comparative conductivity, after passage of current for 5 minutes at an E.M.F. of 15 volts, taking the conductivity from hand to hand as 1.

Longitudinal Currents.	Conductivity	Transverse Currents.	Conductivity
Hand to hand	1·0	Through foot	1·2
Foot to foot	1·3	„ hand ...	2·3
Right foot to abdomen...	2·0	„ chest (side to side) ...	6·4
Left hand to breast ...	2·1	„ abdomen (back and front)	10·8
Left foot to abdomen ...	2·2	„ thigh ...	13·0
Right hand to breast ...	3·0	„ lower leg ...	14·0
Arm (whole)	4·9	„ chest (back and front)	14·0
Fore arm	6·0	„ fore arm ...	20·0
Lower leg...	6·4	„ upper arm ...	23·2
Leg (whole)	9·6		
Front of body	15·6		
Upper Arm	20·0		
Thigh	20·3		
Back of Body	29·6		

These figures indicate that there is less conductivity in all parts of the body to transverse currents than to longitudinal ones, even though the distance between the electrodes is very small in the transverse tests. The conductivity of the trunk lengthways is 29·6, while crossways from side to side it is only 6·4 and back to front (about half the length) its highest value is 14.

A curious feature brought out by these records is, that in no case does the conductivity of a whole limb lengthwise correspond with the sum of that of the two sections of which that length is composed. It is considerably less even when we take into account the additional contacts necessary for the sectional readings. I had hoped to find in the readings some indication of the skin resistance at these points, expecting that the difference between the resistance of the limb as a whole and when taken in sections, would represent the value of the resistance of the additional contacts. For example, the whole arm gives 11,758 ohms, and the sectional readings are 9,758 and 2,588, making a total of 12,346. The difference is, however, only 588 ohms, and in the light of other readings is far too small to fairly represent the additional contacts. We have then to conclude that the greater part of the limb resistance lies in the hand contact or the foot contact as the case may be, and there is indication that this is due not so much to the condition of the skin at these points as to the nearness of bony structure to the surface. This view is somewhat confirmed by the great resistance shown by both the hand and foot when the current was passed through them tranversely.

DIAGRAM I.

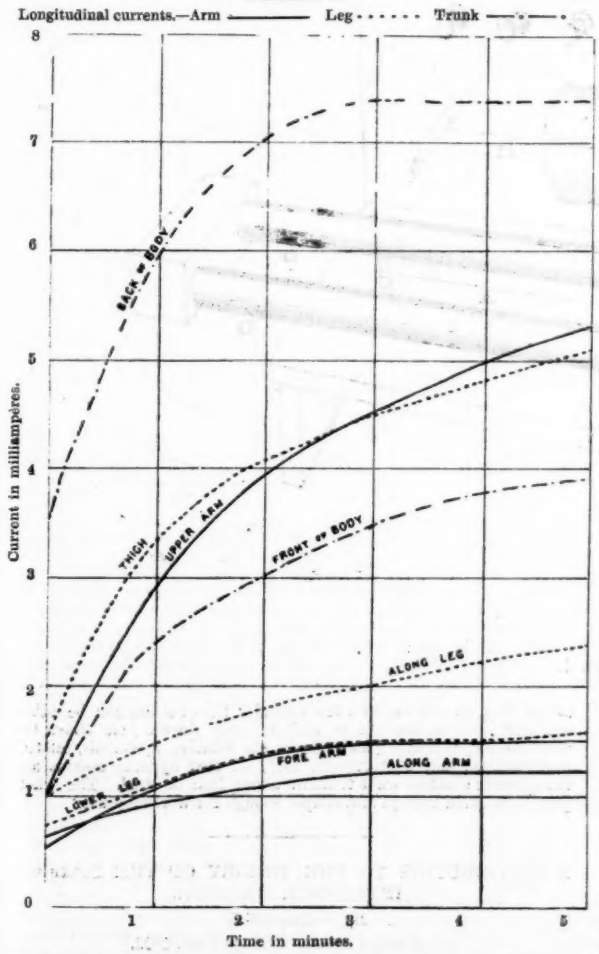
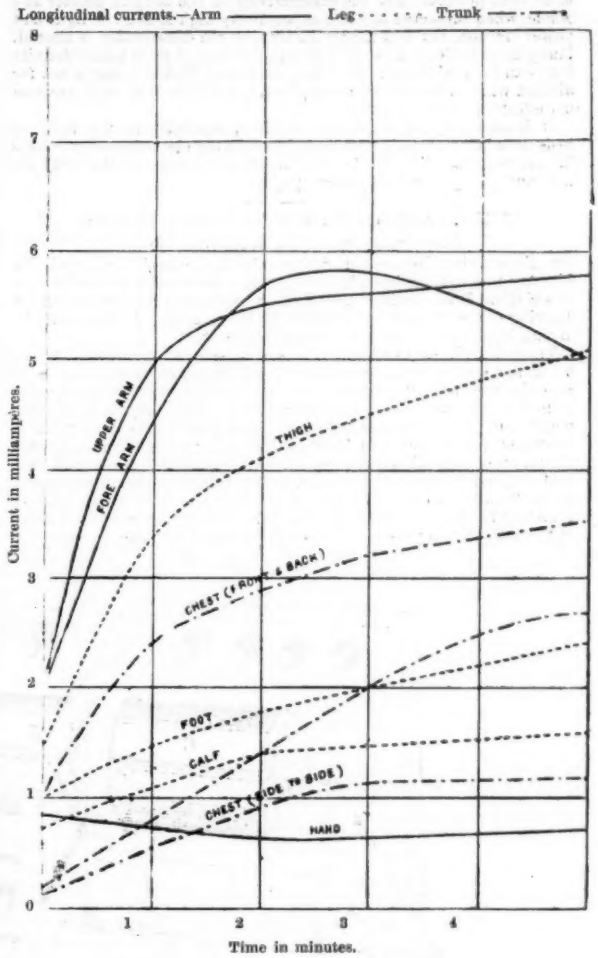


DIAGRAM II.



I next tried the effect of reversals as shown by the following tables:—

TABLE D.

Effects of reversals. Longitudinal currents. The reversals made by hand with an ordinary reversing key at the end of each 5 minutes' passage of current, as in Table A and B.

Position of electrodes.	No. of reversals.	Effect on conductivity.
Arm—Hand and shoulder ...	4	no change.
Hand and elbow ...	4	c reduced by 0·2 ma.
Elbow and shoulder ...	4	no change.
Leg—Foot and hip	4	c increased by 0·1 ma.
Foot and knee	4	c reduced by 0·1 ma.
Knee and hip	2	no change.

TABLE E.

Effect of reversals. Transverse currents. Conditions as in Table D.

Arm—Through hand	4	c reduced 0·1 ma.
„ forearm ...	4	c increased 0·3 ma.
Leg—Through foot	4	no change.
„ calf	4	no change.
„ thigh	4	c increased 0·2 ma.

The small effect of reversals here shown is probably mainly due to the fact that owing to the special electrodes used and the temperature of the strong saline solution within them, the skin at points of contact had become a fair conductor. It has already been shown that when the skin is thoroughly moistened, the difference between the resistance to continuous current and that to alternating current is

very much less than when it (the skin) is dry.*† It seems, therefore, fair to conclude that the precautions taken had the effect of reducing surface polarisation to a minimum.

For the more convenient study of the observations here recorded, I have plotted some curves. Those shown in diagram I. illustrating what happened when the current passed longitudinally, and those in diagram II. what happened when it passed transversely.

These results of experiment are put forward as *indicative rather than conclusive*, because though they are true as far as they go, and under the conditions named, yet individual conductivity varies considerably, and other conditions of test may give other results. It is more than probable that the conductivity of the body is greater as a whole when subjected to the comparatively high E.M.F. of light and power circuits, but it is hardly likely that the distribution is altered. Many more subjects must be tested in a variety of ways before definite laws can be established, but it is to be hoped that the day is not far distant when this shall be accomplished, and I for one will continue my efforts in that direction.

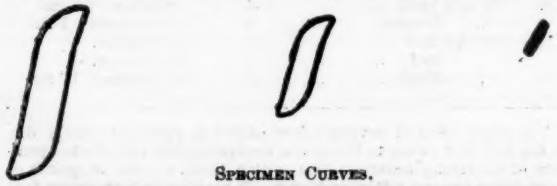
It is necessary to emphasise the fact, especially in the light of resistances to alternating currents found in the electrocuted criminals in America, that the effects of alternating currents on the body are not touched upon in this present paper.

PROF. EWING'S MAGNETIC CURVE-TRACER.

(*Read before Section A, August 9th*, 1892.)

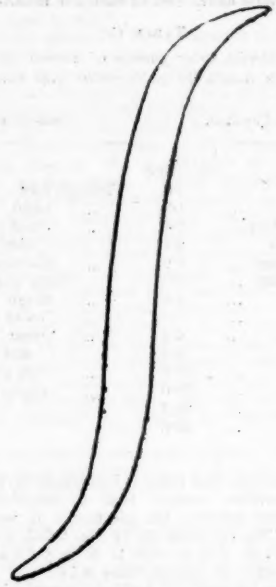
AT his evening lecture on "Magnetic Induction," delivered on Monday last, and again on Tuesday, before Section A of the British Association, Prof. Ewing exhibited an apparatus for automatically drawing curves to exhibit completely the relation of magnetism to magnetising force in samples of any iron or steel.

The principle of the apparatus will be seen at a glance. H (see fig. 1) is a mirror, mounted with two degrees of freedom, capable of altitude and azimuth movement. It receives azimuth movement from the wire, B B, which is stretched in a narrow gap in an electro-magnet, C. It receives altitude movement from a wire, A A, which is stretched in a narrow gap between the pole pieces of the magnetic circuit, D D, consisting of the rods to be examined. A constant current is passed through the wire, A, and it therefore sags, up or down, proportionately to the field across the gap; in other words, proportionately to the magnetism of D D. The variable current which flows in the coils of D D passes also through the wire, B. Hence, since the field of C is constant, L sags out or in, giving the mirror azimuth movement proportional to the strength of the magnetising current. B with its magnet, taken alone, thus forms an extraordinarily dead-beat galvanometer, and A forms an equally dead-beat magnetometer.



SPECIMEN CURVES.

The apparatus can be arranged so that a complete H B cycle can be gone through in $\frac{1}{10}$th or even $\frac{1}{20}$th of a second, the result being a continuous line of light upon a screen. Small loops on the main



SPECIMEN OF A COMPLETE H.B. COIL.

curve can equally well be shown. In the form of the instrument suitable for slower use, it will allow of different materials being tested magnetically with the utmost readiness. A cycle can be obtained from an iron bar in a few seconds; then the bar can be taken out, and another bar put in, and its cycle drawn just above the previous one, so that a glance shows the relative hysteresis, relative permeability, and so forth—in fact, all that dynamo makers and transformer builders want to know about iron or steel. The whole process is quick enough and simple enough for workshop use.

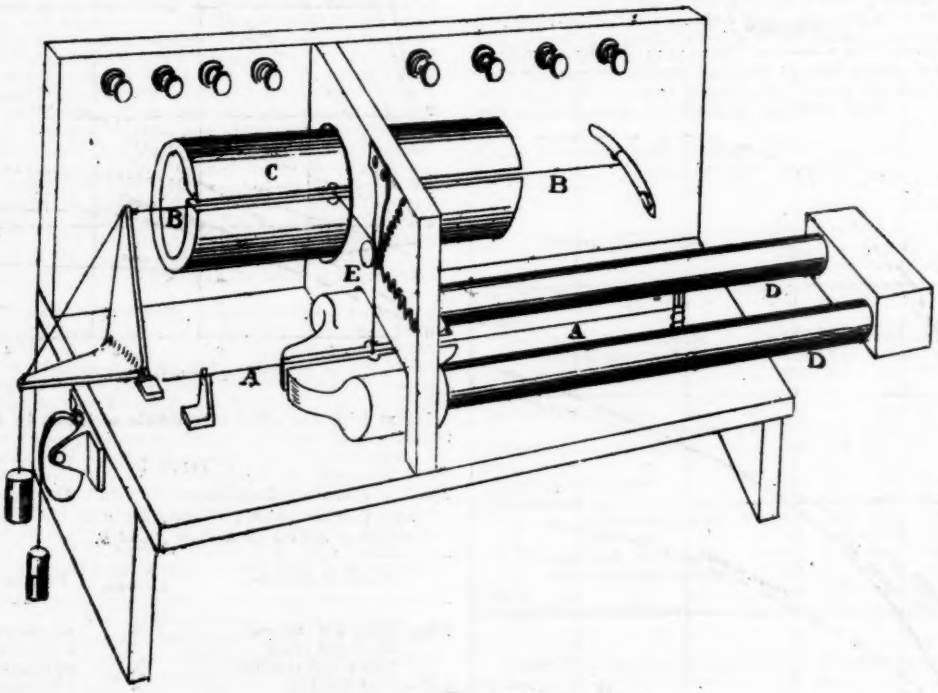


FIG. 1.

A CONTRIBUTION TO THE THEORY OF THE PERFECT INFLUENCE MACHINE.

By J. GRAY, B.Sc.

(*Read before Section A, August 5th*, 1892.)

THE history of the development of the heat engine appears to have repeated itself very closely in that of the electrical influence machine. The early experimental gropings of Savary and Newcomen, in the

* *Journal of Institute of Electrical Engineers*, No. 86, Vol. xix.
† Paper by Mr. Swinburne British Association, Leeds, 1890.

case of the steam engine, run parallel with those of Darwin, Nicholson, and others with the influence machine. These efforts resulted in machines certain, it is true, in their action, but, from ignorance of principles, very inefficient in their design. A closer study of the working of the steam engine, and the application of higher principles by the genius of James Watt, produced a machine of much higher efficiency, and left little for his successors to do except the perfecting of details, till another great advance was made in the theory of the heat engine. The labours of Holtz, extending over a period of 20 years, during which he worked out and perfected in infinite detail, almost all the leading types now in use, has earned for him a good claim to be considered the Watt of the electrical influence machine.

The third stage in the development of the heat engine coincides with the rise in the science of thermo-dynamics; and the investigations of Carnot, Thomson, Rankine, and others showed that the heat cycle through which a mass of working fluid must pass in order to give a maximum efficiency must be made up of adiabatic and isothermal lines. An analagous principle to the above has been applied by Clerk Maxwell to the influence machine, for he has shown that the cycle of the perfect influence machine must be made up of what may be called equiquantic and equipotential lines, corresponding respectively to the adiabatic and isothermal lines of the heat-engine cycle.

The object of this paper is to describe some graphic methods which, I think, help to elucidate the action of Maxwell's machine, and to show by what amount the efficiency of the influence machine may be increased by the application of Maxwell's principles.

Maxwell points out that over and above the loss from leakage, there is a loss of energy in the influence machine through the sparking which takes place just before a carrier makes contact with the charging or discharging points in its course. The energy lost is $\frac{1}{2}$ Q V, where Q is the quantity of electricity transferred, and V the difference of potential producing the spark. The object of his invention is to do away with sparking. He effects this by causing the carrier of electricity to make contact with charging and discharging springs when its potential is the same as that of the spring in question, and to remain in contact during the whole time of charge or discharge.

Fig. 1 is a diagram which will serve to show the action of Maxwell's machine. Conductors are drawn in thick dark lines, and insulators left white, a convention in accordance with the electro-magnetic theory of light.

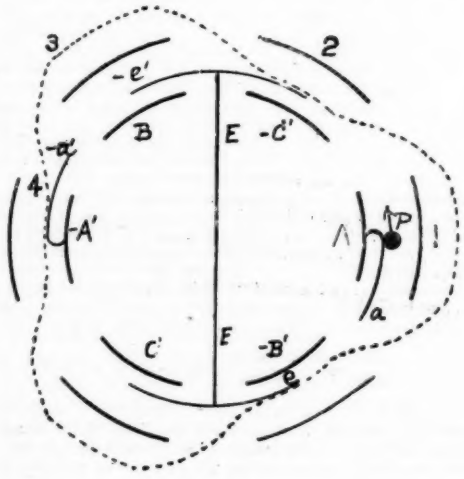


FIG. 1.

The machine consists of six fixed hollow conductors, A, B, C, A^1, B^1, C^1, which may be looked upon as six sections of a hollow anchor ring, separated by insulating air spaces. A conducting carrier, P, is caused to revolve through the centre of the hollow conductors in the direction shown by the arrow. Three of the conductors, A, B, C, are connected to a Leyden jar of large capacity, charged to a positive potential, V. The other three conductors, A^1, B^1, C^1, are connected to another similar Leyden jar charged to a negative potential, V. The conductors taken in order round the ring are thus alternately positive and negative. The dotted line on the diagram is drawn to represent approximately the potential at each point of the circular path through the centre of the conductors along which the carrier, P, travels. The potential at each point is indicated on the diagram by the distance (positive or negative) of the dotted line from the outer circle of the diagram. To the conductors, A and A^1, are connected contact springs, a and a^1; and lying partly inside the conductors, B and C^1, is a spring, e^1, connected to earth or to a similar spring, e, lying partly within the conductors, B^1 and C.

The changes in the energy of the carrier, P, during one complete revolution and the work done upon it are best shown by a Q V diagram, *i.e.*, an energy or work diagram in which the components are the quantity and potential of the carrier.

Let Q O Q, V O V be the axes of co-ordinates; distances along O Q representing quantities of electricity on the carrier, and distances along O V representing potentials of the carrier.

We shall start with the carrier, P, as represented in fig. 1, just about to break contact with the spring, a, which is connected with the conductor, A. The potential of the carrier will be equal to that of A, which we will represent by an ordinate, P N. Its quantity, due to its not being completely surrounded by the conductor, A, may be represented by O P. As O P = V tan P N O, tan P N O equals (with proper units) the capacity of P with reference to the earth. Let tan P N O = α.

The point N, on fig. 2 corresponds, therefore, to the position of P on fig. 1. In passing from its initial position till it comes in contact with the earth spring, e^1, inside the conductor, C^1, P retains its charge unchanged in quantity. We will suppose that S P represents the potential of the carrier, P, when about to make contact with the

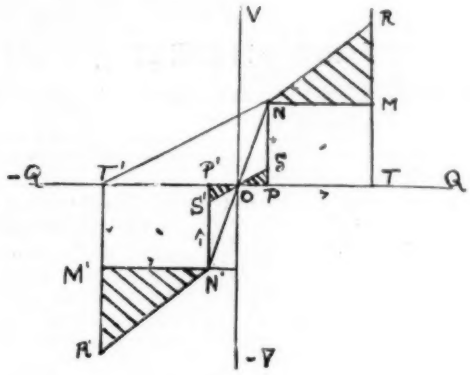


FIG. 2.

earth spring, if the conductor, C^1, were removed. In order to reduce the potential of P to zero, when it makes contact, the coefficient of induction, say c^1 of the conductor C^1 upon P, must be such as to produce an equal and opposite quantity to O P on the carrier, P. Therefore

$$c^1 = \frac{\overline{O\,P}}{V} = \frac{\alpha\,V}{V} = \alpha$$

is the equation for determining the coefficient of induction which the conductor, C^1, must exert upon the carrier, P, at the moment of contact.

The state of the carrier is now represented by the point P on fig. 2. The passage of the carrier along the spring e^1 is represented on fig. 2 by the line, P T^1, during which there is a gradual loss of quantity at zero potential, till the carrier finally leaves the spring with a negative charge represented by O T^1. From contact with the spring e^1 to contact with the spring a^1 the quantity remains constant, but the potential falls—*i.e.*, we pass from T^1 to M^1 on fig. 2. Along the spring a^1 the quantity increases positively, or decreases negatively at constant potential, − V—*i.e.*, passes from M^1 to N^1 on fig. 2. This completes one-half of a revolution, and the other half is exactly similar, though opposite—namely, along N^1 P^1 T M N back to the starting point.

The work done on the carrier in one revolution is equal to twice the area of the rectangle, N T. A quantity, P T, of positive electricity is imparted to the conductor A, and equal quantity of negative to A^1; the potentials of these quantities being V and − V respectively.

The efficiency of the machine in such a cycle is *unity*—that is to say, there is no loss—friction, leakage, &c., being left out of account.

The quantity produced per revolution is less than the maximum possible by the amount left on P when it leaves the discharging conductors, A or A^1.

The conductors C and C^1 are called by Maxwell regenerators, because their function is similar to that of the regenerator in a heat engine.

Let us now, in the first place, consider how much the efficiency of this influence machine is reduced by the removal of the regenerators. The effect of removing C^1 will be to allow the carrier, P, to spark to the spring, e^1, before making contact, and the energy dissipated in this spark is equal to the area of the triangle, S P O. There is a similar loss in the other half of the revolution. The efficiency, E, will now be

$$E = \frac{Q\,V}{Q\,V + \frac{1}{2}\alpha\,V.\overline{S\,P}} = \frac{1}{1 + \frac{1}{2}\frac{\alpha\,.\,\overline{S\,P}}{Q}}$$

This efficiency approaches unity as α or $\overline{S\,P}$ approaches zero, and in an actual machine α can be made very small.

Let us now, in the second place, consider the loss of efficiency due to replacing the long contact springs, a and a^1, by contact points inside the conductors A and A^1. On approaching and entering the conductor A, the potential of P will not stop at M, but will rise to B before discharge.

If the capacity, α, is very small, and the conductors, B^1 and A, have equal coefficients of induction on the carrier, M B will be very nearly equal to M T. The energy dissipated in the spark is equal to the area of the triangle B M N. The efficiency would now be—

$$\text{E} = \frac{1}{1\frac{1}{2}} = \frac{2}{3}.$$

The absence of long contacts in the receivers thus leads to a much greater loss of efficiency than the absence of the regenerators.

CONTACTS		REGENERATOR	EFFICIENCY
CHARGING	DISCHARGING		
LONG	LONG	PRESENT	1
		ABSENT	$\frac{1}{1+\frac{a\,v}{Q}} = 1$
	POINT	PRESENT	$\frac{2}{3}$
POINT	LONG	ABSENT	$\frac{1}{1\frac{1}{2}+\frac{a\,v}{Q}} > \frac{2}{3}$
	POINT		$\frac{1}{2+\frac{a\,v}{Q}} > \frac{1}{2}$

If points are substituted for long contacts in the charging conductors, B and B^1, a moment's inspection will show that the loss by each spark is the area of the triangle P N T^1.

Then
$$\text{E} = \frac{Q\,v}{\frac{1}{2}(Q + 2\,a\,v)\,v};$$
$$= \frac{1}{1\frac{1}{2} + \frac{a\,v}{Q}} < \frac{2}{3}.$$

Finally, when all the contacts are points, as in the ordinary influence machine, the efficiency

$$\text{E} = \frac{1}{2 + \frac{a\,v}{Q}} < \frac{1}{2}$$

I have made a machine with long contacts, but without regenerators, which is self-exciting, and gives considerable quantity; but owing to difficulties of insulation, which I hope soon to overcome, I have not been able to get long sparks.

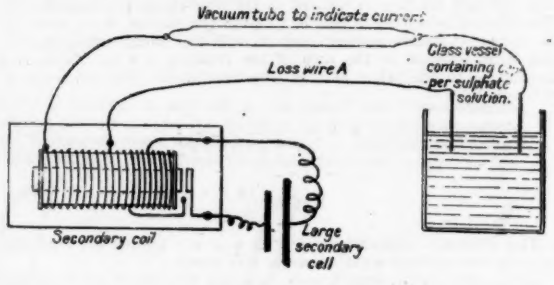
These graphic methods may be applied to any influence machine for investigating their efficiency.

SOME EXPERIMENTS WITH A RUHMKORFF COIL.

By MAGNUS MACLEAN, M.A., F.R.S.E., and ALEX. GALT, B.Sc., F.R.S.E.

(Read before Section A, August 5th.)

THE quantity of electricity induced in a secondary circuit by a *make* in a primary circuit is equal to the quantity of electricity induced in the same secondary by a *break* in the primary. This fact was first experimentally proved by Faraday, and subsequent experiments and theory corroborate the statement. If, however, there is a non-metallic gap in the circuit, whether of air at ordinary pressure, or at much reduced pressure, as in vacuum tubes, the *break* impulse causes a flow in one direction, and the *make* causes either no flow, or a much less flow in the opposite direction; because the short intense impulse of the former breaks down the resistance, while the comparatively long and less intense impulse of the make either does not break down the resistance at all, or only does so to a much less degree, so that the effective resistance is much greater in one direction than in the other. To obtain the average difference of quantity of electricity set in motion in one direction above that in the other, a copper electrolytic cell was put in circuit with a vacuum tube, and the secondary coil of a



small Ruhmkorff coil. The solution in the cell was sulphate of copper of density 1·17, with one-half per cent. of commercial sulphuric acid added. The electrodes were No. 36 B.W.G. copper wire, 0·012 centimetre diameter, and they were immersed in the solution as little as possible, so as to get the best current density for the deposit. The mean of seven experiments, lasting from two to four hours gives the average electrolytic current, calculated from the gain of the cathode electrode, as one-sixth of a milliampère. The gain of the cathode electrode was, in six of the seven experiments, greater than the loss of the anode electrode. An electrolytic cell was also put into the primary, and the mean ratio, in three experiments, between the gain of the cathode in the primary and the gain of the cathode in the secondary, was 6,000. The mean current in the secondary was still about one-sixth of a milliampère.

One or two experiments were also tried without a vacuum tube in the secondary circuit, simply the electrolytic cell. Both electrodes showed loss. Again a long thermometer tube full of sulphate of copper solution was substituted for the vacuum tube. The resistance of this tube would be comparable to that of the vacuum tube. (A Thomson multicellular was put at the terminals of the vacuum tube, which showed 165 volts. This would give the effective resistance of the vacuum tube to disruptive discharges as $165 \div \frac{1}{6000}$ = one megohm.)

The few experiments done with this thermometer tube in the circuit are inconclusive, as sometimes both electrodes showed loss, and in an experiment lasting hours, neither electrode showed either gain or loss. These last experiments are to be continued with slight modifications. It is also intended to attach a tube to an exhaust pump, and try these electrolytic experiments at different pressures, from atmospheric pressure down to very low pressures or very high vacuums.

SOURCES OF HEAT GENERATED IN THE GALVANIC BATTERY.

By MAGNUS MACLEAN, M.A., F.R.S.E.

(Read before Section A, August 6th.)

These experiments were suggested by a paper read by Lord Kelvin to the British Association in Belfast in 1852, and reprinted in "Mathematical and Physical Papers," art lv. In that article it is stated "that a feeble continued current, passing out of an electrolytic cell by a zinc electrode, must generate exactly as much more heat at the zinc surface than the same amount of current would develop in passing out of an electrolytic cell by a platinum electrode, as a zinc platinum pair working against great external resistance would develop in the resistance wire by the same amount of current."

In the first set of experiments, two equal and similar glass vessels were used, with about 500 cc. of dilute sulphuric acid in each. The pairs of elements were Zn Zn, Zn Pt. The rise of temperature due to currents of from 4 to 14 milliampères, obtained from the Smee cell, was observed at intervals of a few minutes for about four hours. There are many sources of error in this mode of experimenting, besides the difficulty of observing the small rise of temperature; but generally the rise of temperature of the Zn Zn cell was greater than that in the Smee cell. In some of the experiments the Smee cell showed a higher rise of temperature, but this latter result is no doubt due to local causes, such as polarisation, &c.

In the second set of experiments, a current of 39 milliampères was obtained from the Smee cell, and in every case the rise of temperature of the Zn Zn cell was greater than the rise of temperature of the Smee cell; and the average rise corroborates the statement of Lord Kelvin quoted above.

Thus average rise of temperature of Zn Zn cell above Smee cell is 0·2° C., and hence heat generated = 500 × ·85 × 0·2 = 85. Equating this to the work done by Smee cell in four hours, we get:

$$\text{E} = \frac{85 \times 42 \times 10^6}{\cdot0039 \times 4 \times 3{,}600} = \cdot64 \times 10^8 = \cdot64 \text{ volt.}$$

In the third set of experiments the two elements in each cell were separated by a piece of blotting paper, and four thermometers used to indicate the rise of temperature at each electrode. It was found that the rise of temperature at the zinc anode plate was greater than at the zinc cathode.

In another series of experiments with four cells containing dilute sulphuric acid, in which the pairs of elements were Zn Zn, Pt Pt, Pt Zn, and Zn Pt, currents from an external source of half, one, and two ampères were allowed to flow for about an hour, and the rise of temperature in each cell recorded. Tables of results are given showing that the rise of temperature in the cell in which the current flowed from platinum to zinc, is in every case higher than the rise of temperature in the cell in which the current flows from zinc to platinum. Taking the average of a number of experiments fairly agreeing among themselves, it is found that the mean rise of temperature in the four cells is:—

Time experiments lasted.	Current in ampères.	Zn Zn.	Pt Pt.	Pt Zn.	Zn Pt.
1 hour	$\frac{1}{2}$	0·45	0·6	0·53	1·07
40 minutes ...	1	0·45	0·75	0·6	1·37
1 hour	2	2·8	3·98	2·53	4·98

Direction of current <———

Mr. George E. Allan, Thomson Scholar in the Physical Laboratory of the University of Glasgow, carried out the larger number of the later experiments.

NOTES.

The New Telephone Company.—Mr. Julius Maier, writing to the *Financial News*, comments regarding the New Telephone Company as follows :—"The above is altogether a misnomer. It is not a new company at all whose prospectus was issued last week ; it is our old friend, the National in disguise—the wolf in sheep's clothing—raising the wind to the tune of another £750,000. The cat is out of the bag! That splendid institution, the New Telephone Company, which has been brought out by the Pioneer Telephone Company, which has been brought out by the Electric and General Investment Company, which bought up the Mutual Telephone Company—what is it after all? It was to give us an improved telephone service in London ; it was to be started in opposition to the National—in fact, that opposition was its only *raison d'être*. It espoused the cause of the Association for the Protection of Telephone Subscribers who had been ill-treated by the National for the last 10 years, it obtained several thousand subscribers on that plea of opposition, and now it turns out to be nothing but another of those financial speculations in which the history of electrical applications is so rich in this country, and which are mainly responsible for the lamentable condition of telephony in England. Four of the eight directors of the New Telephone Company are also directors of the National, and this latter company subscribed £250,000, or one-third of the entire capital. This, of course, means that the New Telephone Company, if they ever begin to do any telephonic work—which I am inclined to doubt—will be managed on the same lines as the National, that the present disgraceful state of affairs will be perpetuated, that the subscribers will be ill-treated and snubbed more than ever, that the present exorbitant rates will be continued, and that the progress of telephony in England, as has been the case with the progress of electric lighting, will be artificially checked for the next decade. The policy of the National is not likely to be altered now that they have achieved their great object of an absolute monopoly, and I certainly think that a grosser breach of faith has never been perpetrated than the handing over of the members of the Association for the Protection of Telephone Subscribers to the tender mercies of the National. At the meeting on May 5th of this year, when the agreement between the New Telephone Company and the Association was ratified, it was distinctly stated that the committee of the Association having obtained no redress of their just complaints from the directors of the National—in fact, having been treated with rudeness and contempt by that august body—had approached the New Telephone Company with the same object, and had obtained from them the assurance of a better service at a cheaper rate. And now we find the New Telephone Company, which had given that assurance, amalgamating with the National, and the 3,000 or 4,000 London subscribers who, on the strength of it, had joined the New Telephone Company, transferred in a body, and without asking their consent, to the arbitrary ruling of the very men who had insulted the representatives of the Association formed for the protection of their interests! I should think that the committee of the Association will have something to say to this bargain. They ought to call a general meeting forthwith, and ought to propose that the members, one and all, withdraw their names from the list of subscribers of the New Telephone Company, thus marking in the only effective manner possible their disapproval of a course of action which is most reprehensible and most unfair." [Apparently a very reasonable suggestion, but calculated, we fear, to play into the hands of the combination.]

Electrolytic Gas.—Further experiments on the stability of electrolytic gas and its combustion temperature have recently been made by P. Askenary and V. Meyer. They find that when every precaution is taken to facilitate combustion no appreciable combination takes place, when the gas is kept at 100° C., even when exposed for four hours. Moist electrolytic gas was also exposed to the concentrated light of a July sun, and at the same time was heated to 606° Centigrade, without any explosion occurring. It is certain that this gas is far more stable than it has by some been represented to be.

State Acquisition of the Telephones in Belgium.—Several journals (says the *Indépendance Belge*) are endeavouring to tranquilise the staffs of the different Belgium telephone offices whom the news of the acquisition by the Government had disquieted. All the staff, it has been said, will be re-engaged after December 31st next, though it is decided that all telephone operators will have to undergo an examination, without prejudice to the conditions to be imposed individually on the higher officials. The telephonists imagined that the subjects of that examination would simply include the knowledge special to the manipulation of the apparatus, and they were without disquietude as to the result of the examination. But the programme arrived officially at the different offices : great and painful was the emotion when it was found that most of the questions were those which the majority of the present *employés* were unable to answer. From future State telephone operators a thousand things are required, which were absolutely ignored by the company's operators. In addition to the two national languages (French and Flemish), German, English and geography become obligatory. A complete sketch of the map of Europe is imposed on candidates. That it is important to possess, in each central office, one or several operators having a knowledge of English and German, we are quite aware ; we also understand that, in future, since there is always a choice in a large number of competitors, preference will be given to the best educated ; that is but just. But we believe that too much is required from the old *employés* in asking that each one of them should speak the four languages. Despite these requirements, the salaries will be largely reduced, some of them 33 per cent. Ladies who have been connected with the telephone for nearly 15 years, are obliged, from December 31st next, to seek other employment, for they cannot get up all the subjects of the examination in five months, especially as they have to work as well. As may be imagined, all the offices are on the alert, and the Ministry is being heartily cursed. Efforts are being made in order to obtain a modification of the warrant instituting the examination.

The Electric Light at Bow.—The New Eastern Empire Music Hall, now in course of erection in Bow Road, E., is to be lighted throughout by electricity.

Electric Lighting in Oldham.—A Local Government enquiry was held last week at the Oldham Town Hall, before Colonel John Ord Hasted, R.E., the inspector appointed by the Local Government Board, in reference to the application of the Corporation for borrowing powers not exceeding £40,000 for electric lighting purposes. The Town Clerk made an explanatory statement to the inspector. He said that the plant proposed to be put down would supply simultaneous lighting for about 2,500 glow lamps of 8 candle-power each. The engineer's estimate of the cost of the works contemplated to be carried out forthwith amounts to, exclusive of land, £21,000. The Corporation ask for borrowing powers for £40,000, in order that they may be in a position to increase the supply when necessary. The Corporation propose to light up as early as possible the Town Hall and municipal buildings and offices, Free Library and Art Gallery, Science and Art Schools, the School Board Offices, and Oldham Infirmary. They have caused enquiries to be made from tradespeople, banks, and others as to whether or not they are likely to take supplies of electricity, and the Corporation anticipate that close upon 2,000 lights will be taken up as soon as the supply can be given. Prof. Kennedy then explained details as to the site of the works and the cost. The batteries to be used for electric lighting purposes in the daytime would, he thought, be sufficient for a long time to come. They would keep 200 lamps alight for eight hours. The cost he estimated as follows :—The plant, including everything stationary, £8,800 ; the mains, £5,600 ; the buildings, £6,000 ; the meters, £600. He thought those prices were full. The inspector stated that the Local Government Board would only grant at present the amount of the estimate. The Town Clerk therefore asked that £4,000 be added for purchase of land, and something for contingencies, thus making the estimate £26,000. The enquiry then concluded.

Medical Electricity and the Royal College of Physicians.—Our plain-speaking contemporary, *Truth*, has recently published a trenchant article upon the action of the Royal College of Physicians and the late Institute of Medical Electricity, Limited. It points out that the Institute had the support and recommendation of many of the leading electricians of the day, but that in spite of this and the acknowledged *bonâ fides* of the undertaking, the R.C.P. thought fit to prohibit two of its members from acting as medical officers on the pain of being deprived, one of his fellowship, and the other of his membership. This action *Truth* goes on to say (and we quite believe it) had the effect not only of depriving the Institute of the services of two of the best known and most respected electrical specialists in the profession, but of practically boycotting the Institute altogether, and *eventually starving it out*. The article concludes with a direct challenge for an explanation from the College. Surely even so eminently conservative a body as the R.C.P. must have something to say to such an indictment. Electricians generally will await their reply with interest. What a curious comment this action of the R.C.P. in stifling a genuine effort of reputed electricians forms to the state of things existing under the name of Medical Electricity exposed the other week in the Bloomsbury County Court.

Electricity in the City of Paris.—The Municipal Council has recently voted the reorganisation of the services of the City of Paris. This step is of special interest to electricians, as an official service will be established, to commence operations on January 1st, 1893. There will be a special electric lighting service, and an official surveyor will be appointed as controller of all the electrical companies in Paris, and also as inspector of all the electrical meters installed in Paris.

Electricity on the Croydon Tramway.—At the fifth annual meeting of the Croydon Tramways Company, held at the Guildhall Hotel, on Tuesday, Mr. W. J. C. Wain, the chairman, said the electric traction experiment had given satisfactory results on the company's lines, as the cars were largely patronised by the public, with the result that they earned £167 14s. 7d. on 3,323 miles run. The payment to the Electric Car Syndicate, therefore, was £81 15s. 9d., as shown in the accounts, while the number of passengers carried on the electric line was 25,649. He added that the directors had no cause to regret the electrical experiment which they had permitted on their lines, nor were they averse to continuing it.

The Dundee Mechanical Society.—On Saturday next, 13th inst., the members of the above society intend making an excursion to inspect the electric light installation at May Island Lighthouse. On the 27th inst. they will go on a similar excursion to see the Telephone Exchange at Panmure Street, Dundee.

The Electric Light at Reading.—At a meeting of the Reading Town Council it was reported that the Reading Electric Supply Company intended applying to the Board of Trade for a provisional order. The borough engineer, and Mr. McMullen, electrical engineer, presented an estimate for a system of house-to-house supply, the total cost of which was put down at £52,000. It was added that if it was considered desirable to light certain streets with 40 arc lamps, the additional cost would be £3,000. The committee recommended the Council not to consent to the application of the company, but to make application to the Board of Trade to authorise the Council, as the local authority, to supply electricity. After a short discussion, it decided that the question should be considered at a future meeting of the Council.

The Electric Light at Portsmouth.—The Electric Lighting Committee of the Portsmouth Town Council have been engaged in carefully considering the details of the specifications upon which tenders for the first installation will be taken, and it is understood that advertisements, inviting competition, will be published shortly. The committee anticipate that by the summer of next year the whole of the sea front at Southsea will be illuminated by means of the electric light.

The Tokyo Electrical Society.—The Tokyo Electrical Society in Japan now has a membership of 1,213.

The Electric Light in Sussex.—The Hastings Town Council had under consideration last week a report from the Lighting Committee recommending that electric lighting should be extended along the whole three miles of the front line. After a discussion, however, the proposal was deferred for further consideration. The Brighton Town Council dealt last week with a report from their Lighting Committee, recommending that a deficiency of £283 on the working of the electric light should be paid out of the General District Rate. Objection was taken because of the meagre accounts with which it was said the committee had furnished the council and the public. The Mayor, however, remarked that the accounts were made out according to the regulations of the Board of Trade, and a councillor expressed a belief that in time the electric light would be a source of great profit to the town. The protest was withdrawn, and the committee's recommendation adopted.

Telephony in France.—A new telephonic system has just been established between Paris and Maisons-Laffitte, in the department of Seine-et-Oise. The inauguration of the line took place on the 5th inst., in the presence of the Mayor of Maisons-Laffitte.

The German Electric Lighting Bill.—With reference to this Bill, Dr. Fischer, director of the Imperial Post Office, states in *Schmoller's Jahrbuch*, that during the negotiations in the Diet, concerning the Telegraph Bill, the question as to the protection of electrical installations could not be solved, but that on the contrary, it was only temporarily settled by compromise.

The Multitubular Accumulator.—M. D. Tommasi's multitubular accumulator, which has so often been discussed, is at length in the hands of the manufacturer. Messrs. Rouart Brothers, Paris, have undertaken its construction. Catalogues relating to it have appeared, and three types of the apparatus are established. The charge varies from 1 to 4 ampères per kilogramme of plates, and the discharge from 1 to 3 ampères per kg. The available capacity in ampère-hours, under a discharge of 1 to 3 ampères per kg., is 20 ampére-hours per kg. The price of the accumulators is ·30 fr. per ampère-hour. Everyone will remember that the Tommasi multitubular accumulator is formed of electrodes enclosed in a sheath of insulating material pierced with a number of little holes. In the centre of the sheath is a leaden conductor in contact with a layer of oxide. The industrial application of this system has often been discussed, but, until now, nothing has been done in the matter.

Dynamo with Bi-metallic Armature.—Messrs. Ch. Reignier and G. Parrot have just constructed a new dynamo with a bi-metallic armature, according to the description given in *Le Génie Civil*. In this machine the winding consists of *bi-metallic* plates, *i.e.*, of thin plates of soft iron, all the surfaces of which are enveloped in layers of copper. These plates are wound carefully, being insulated from one another, and the winding is performed so as to form a flat even ring, The soft iron which is thus inside the armature should increase the permeability of the core, and at the same time act as a conductor of electricity. Messrs. Reignier and Parrot have constructed a machine based upon these principles. This machine, which weighs 750 kilogrammes, gives a power of 32,000 watts, or 42 watts per kilogramme. The best machines as yet known have not, it is said, exceeded 26 watts per kilogramme (Rechniewski) and 24 watts (Desroziers). The machine we are describing contains 4 inductors with alternate magnetic fields, and the armature had 264 bobbins grouped in fours in quantity. The angular speed is 500 revolutions per minute. We will confine ourselves now to a mere notice of the machine, and describe it more in detail if there is occasion to do so. M. Reignier has several times claimed to have invented a very powerful dynamo, but his efforts have not always been crowned with success.

Lighting Small Towns.—Dourgne, a little town in the Department of Tarn, in France, will shortly be lighted by electricity with the aid of hydraulic motive power. A stream near gives a supply of 15 litres per second. A dam has been made 6 metres in height, and a reservoir of 1,500 cubic metres formed. The water flows from this reservoir to the works with a fall of 65 metres. A turbine works a Gramme machine of 110 volts and 80 ampères, which enables 140 16 candle-power incandescence lamps to be maintained.

The Underground Electric Canalisations at Paris.—One of the greatest defects in underground electrical canalisations, besides the defects in insulation which may exist, is certainly the want of ventilation in the channels made. When the cables are placed in them the openings are closed up, and the air becomes foul, and may cause serious accidents. Ventilation by shafts dug at intervals is not sufficient. It is necessary to perform from time to time a thorough artificial ventilation. We believe, moreover, that this plan has been found to be necessary in the various large towns in which subterranean canalisations have been made. The City of Paris has only been compelled to adopt this precaution, and the municipal electrical service uses a special movable ventilator, placed at intervals, to ensure ventilation. We may add that in Paris the quantities of gas escaping from the conduits and spreading over the ground attracted public attention. In 10 minutes the air can be renewed over a length of canalisation of 600 metres. This apparatus is simply an ordinary ventilator, with nothing special about its construction, although M. Monmerqué expresses a contrary opinion in *Les Annales Industrielles*, July 13th, 1892.

The Distribution of Electrical Energy at Lyons.—The town of Lyons has just taken an initiative in France, which is worthy of notice. It has obtained from the Government a law recognising as of public utility a distribution of electrical energy, produced by a waterfall derived from the Rhone above Lyons. A splendid syndicate has been formed under the title of *Lyons Syndicate of the Forces of the Rhone.* Above Lyons, a canal leading from the Rhone will be made. This canal will be 18·6 kilometres long, and will pass through the communes of Jons, Jonage, Décines, Vaux-en-Vélin, and Villeurbanne, terminating at an electrical station at Cusset. The volume of water supplied thus will be 100 cubic metres per second, and will be capable of attaining to 150 cubic metres per second when the river yields 600 cubic metres. The fall of water will be about 12 metres, and the power obtained 12,000 H.P., which will be distributed by electricity over the neighbouring communes. For 99 years the company will have the right to sell the electrical energy produced at the works, and also the right of fishing in the canal. The company will have to pay 2,500 francs a year for the water used, and a due of 0·10 francs per running metre of canalisation. The energy is supplied to consumers of less than 1 horse-power by tenths of a horse-power at the rate of ·027 francs per hour or 72 francs a year. Above 1 H.P. the price is ·27 francs per H.P. per hour. This is reduced to ·20 for a motor of 10 H.P. to ·13 francs for 25 H.P., and to ·03 for motors of 50 H.P. It will be interesting to follow up this undertaking and note its progress.

Electrical Works at Cambrai.—We are glad to learn that the electrical works at Cambrai, after having been closed for a year, are about to be reopened. M. E. Launy will again be at the head of affairs. We hope that all difficulties are things of the past, and that the central station at Cambrai will now have an uninterrupted success.

The Electric Light for Wolverhampton.—At the meeting of the Wolverhampton Town Council on Monday last, the Chairman of the General Purposes Committee moved :—"That the following resolution, passed at a meeting of the Council in committee, held on the 20th day of July, 1892, be approved and adopted, viz. :—'That the report of the Lighting Committee, as to the supply of electricity for public and private purposes within this borough be received and adopted, and that the General Purposes Committee be authorised to advertise for tenders for the construction of all necessary works for the supply of electricity within the area mentioned in the report, and to submit the same to the Council for approval.'"

Electric Lighting in Dublin.—According to the *Irish Times*, last Friday afternoon the official testings of the electric light installation were commenced at the central station, Fleet Street, Dublin, under the direct supervision of Mr. Robert Hammond, of the firm of Hammond & Co., who have carried out the whole work ; Mr. E. Manville, of London, electrical engineer to the Corporation of Dublin ; and Mr. Spencer Harty, city surveyor. The members of the Electric Lighting Committee of the Corporation visited the works during the evening, and evinced the greatest interest in the running of the plant.

Tunbridge Wells and Electric Lighting.—The Tunbridge Wells Electric Lighting Committee have decided to appoint Mr. W. H. Preece as consulting engineer to the corporation, at a fee of 100 guineas and out-of-pocket expenses, for the purpose of advising the corporation how best to make use of the powers conferred on them by their electric lighting provisional order, advising the corporation how to proceed, preparing estimates of the necessary capital outlay and maintenance charges, preparing the specification, and reporting on the tenders received in response thereto.

New Publication.—The first number of a new monthly paper, called the *Monthly Messenger*, has just been issued. It is issued and published by the London and Suburban and General Agency Company. Being the company's organ, it will contain a chronicle and review of all matters of interest relating to the "perfection of communication."

Lane-Fox v. Kensington and Knightsbridge Electric Lighting Company.—Judgment was delivered on Wednesday last, in the appeal by Mr. Lane-Fox from a decision of Lord (then Mr.) Justice A. L. Smith. The appeal was dismissed with costs. We shall give a full report of the case in our next issue.

Obituary.—We regret to hear of the death of Monsieur Maurice Simon, of Paris, who was well known to a few of our readers who were connected with the 1881 Electrical Exhibition at Paris. He himself was a foreign member of the Institution of Electrical Engineers, and was largely interested in the introduction of the Swan patents into France, being one of the directors of the Edison-Swan Company there, and also for some time director of the Société des Téléphones of Paris. He was a member of the firm of Simon and Allain, late Fessard and Simon, of 83, Rue Charlot. He was educated in England, and his genial manner and excellent knowledge of English, made him many friends among the people of this country who had the pleasure of knowing him. He died at the comparatively early age of 41, and leaves a widow and four children.

Incandescent Lamp Manufacture.—A correspondent writing from Gothenburg (Sweden) says :—"I have just noticed in your issue of July 29th, an article under the heading of "Incandescent Lamp Manufacture," in which the writer mentions "fifteen-penny lamps," and I therefore thought it might be interesting to you to learn that we are using in our central station here, incandescent lamps of all voltages up to 125, made by Swedish manufacturers, at 9½d. each, and we are offered others by a maker in Buda-Pest at 9½d."

Yarmouth and the Electric Light.—At the quarterly meeting of the Town Council on Tuesday, at Yarmouth, the Town Clerk reported that he had received tenders for an electric light installation for the town from several firms. The tenders varied from between £5,000 and £6,000 to £23,000. Mr. W. H. Preece has been appointed to advise the Corporation and also to examine the tenders and specifications for 50 guineas, exclusive of out-of-pocket expenses.

The Production of Caustic Soda and Chlorine.—A new process for the electrical production of caustic soda and chlorine has for some months been in experimental operation at Snodland, on the banks of the river Medway. The works of the owners, the Electrolytic Caustic Soda and Chlorine Company, were recently visited by a correspondent of *Paper Making*, who states that the plant is capable of turning out from 10 to 20 tons weekly.

BUSINESS NOTICES, &c.

Cathcart, Peto & Radford.—An installation of some importance has recently been completed by Messrs. Cathcart, Peto and Radford at Messrs. C. Brown & Co.'s steam flour mills, Waddon, Croydon. The mills in question were formerly, it seems, inadequately lighted by 50 gas burners of about 12 candle-power each, at a cost of something like £80 per annum, and it is anticipated that the new electrical installation, which is equivalent to about 200 16 candle-power lamps, will cost in extra steam consumption not more than what was previously paid for gas, the use of which was prohibited in some parts of the mill, because of the risk attending contact with flour dust. The installation requires about 20 horse-power, which is taken from a very fine horizontal engine of 400 horse-power effective, used in the milling. The dynamo is of the Brush Victoria type, giving 110 volts at 1,200 revolutions. There are no accumulators. The switchboard divides the wires into three main circuits, viz.: (1) the warehouse; (2) the new mill; (3) the old mill, offices, stables, &c. The double-pole switch turns on the whole of the circuits at once, each floor having a separate switch. The whole of these accessories, it may be added, have been manufactured by Messrs. Cathcart, Peto & Radford. A speciality of the installation is that the lamps are fitted up to the joists in such a manner as to minimise breakage, and as an extra precaution protecting globes are used throughout, fitted with an India-rubber ring so as to render them dust proof, this arrangement being Messrs. Cathcart, Peto & Radford's patent.

At Mr. Radford's private residence, South Park Hill Road, Croydon, an installation was laid down some time ago, consisting of a 1 horse-power nominal Campbell gas engine, and a 1-unit dynamo of the E. P. type, with switchboard and accessories. In a closet near the house are stored 22 E.P.S. accumulators. In the house there are altogether about 40 16 candle-power lights, distributed through every room and the lavatories, and the fittings are of a superb character, while the light is absolutely steady and under complete control, being regulated by means of switchboard on staircase to three degrees of intensity. The garden also, it may be added, is illuminated. A similar installation has recently been fitted up by Messrs. Cathcart, Peto & Radford for Mr. Lloyd, of the *Daily Chronicle*, at his mansion, Shirleyhurst, near Croydon.

Northern Electric Wire Company v. Fowler, Lancaster & Company: Goods Sold.—This was an action in which the Northern Electric Wire Company, Limited, of Halifax, sued Messrs. Fowler, Lancaster & Co., of Birmingham, for the recovery of £66, alleged to be due for cables, wire drums, and other goods supplied. Mr. E. Tindal Atkinson, Q.C., and Mr. Palmer, appeared on behalf of the plaintiffs, and Mr. T. W. Chitty represented the defendants. The case set up for the defence was that there had been an overcharge made in respect of some of the goods, and that certain allowances which should have been made for returns had not been made. The defendants also claimed £900 as damages for non-supply of electric cables within a reasonable time, whereby it was alleged that the defendants suffered damage owing to being unable to complete the system of electric lighting on three battleships which were being built for the Admiralty at Messrs. Palmer's shipbuilding yards at Jarrow-on-Tyne. A verdict for the plaintiff was given for £39 11s.; on the counter-claim he gave a verdict for £58 15s. 3d. The blame on both sides being great, he disallowed all costs.

Electric Lighting of Bilston Market Hall.—This new Market Hall, which was formally opened on the 9th inst. by Sir Alfred Hickman, M.P., is noteworthy in being entirely dependent upon electricity for lighting. The interior is lighted by eight (2,000 C.P.) arc lights, and by 74 incandescence lamps of 16 C.P. in the closed stalls, offices, &c., and the exterior by two 2,000 C.P. arc lamps. The whole of the plant, including loco. boiler, engine and dynamo, has been supplied and erected by the Brush Electrical Engineering Company, Limited, through their Manchester branch, to the requirements of the Township Surveyor, Mr. C. L. N. Wilson.

Tenders Wanted—Manchester.—The gas committee of the Corporation of Manchester are prepared to receive tenders for the supply of an electrical crane, at their electric light station, Dickinson Street. General conditions of contract and specifications can be obtained on application, in writing only, to Mr. C. Nickson, superintendent of the gas department, Town Hall, Manchester. The committee do not bind themselves to accept the lowest or any tender. Sealed tenders, addressed to the chairman of the gas committee, and endorsed "Tender for crane," must be delivered at the gas offices, Town Hall, not later than 10 a.m. on Friday, August 19th, 1892. Wm. Henry Talbot, Town Clerk.

Tenders Wanted—Croydon.—Offers are invited for the transfer of the powers granted to the Council under the Croydon Corporation Electric Lighting Order, 1891. Tenders should state the terms offered, the system of lighting proposed to be adopted, and it is essential that an option should be reserved to the Council of repurchasing the undertaking upon terms to be named. Tenders should be sent to Mr. C. M. Elborough, town clerk, Town Hall, Croydon, endorsed "Tender for electric lighting order," by 11 a.m. on September 15th.

Tenders Wanted—Germany.—Tenders are being invited, until October 31st next, by the General Direction-Grossh Badische Staatseisenbahnen, at Karlsruhe, for the electric lighting of the central goods station at Mannheim.

Tenders Wanted—St. Pancras.—Tenders are being invited for the following, for the Vestry of St. Pancras: 1. Supplying about 50 cast iron columns for arc lamps. 2. Supplying, fixing, and setting to work about 50 arc lamps, to be worked 11 in series by existing high tension machines, drawing cables through pipes, providing switches, making all connections. 3. Supplying high tension cables. 4. Supplying cast iron pipes for cables. 5. Erecting the cast iron columns, laying cast iron pipes, constructing manholes with cast iron covers. Drawings, showing the positions of the arc lamps and the construction of the manholes, covers, pipes, &c., can be seen at the offices of Prof. Henry Robinson, C.E., 13, Victoria Street, Westminster, where copies of the several specifications can be obtained on payment of 2s. each. Tenders to be sent to Mr. A. E. Pycraft, chief clerk, electricity department, Vestry Hall, Pancras Road, N.W., by 22nd inst.

Tenders Wanted—Telegraph Poles.—Tenders are invited for the supply of hard-grown larch telegraph poles. The poles must have been felled between November 1st, 1891, and February 29th, 1892, and be ready for immediate delivery, or they must be felled between November 1st, 1892, and February 28th, 1893, and be delivered as soon as possible after the last-named date. Forms of tender, containing all particulars, may be obtained on application to Mr. Chas. E. Stuart, controller of stores, Telegraph Street, London, E.C. Tenders will be received until noon on 22nd inst.

Tenders Wanted—Algeria.—The civil authorities of Bougie, Algeria, are inviting tenders, until March 31st, 1893, for the lighting of the town either by gas or by electricity.

The Electric Light in the City.—The adoption of electric lighting in the City is still progressing in a most satisfactory manner. Since our last report we note that Messrs. Crompton & Co., are carrying out an installation in the premises of the London and Scottish Issue Company, Lothbury.—The Brush Electric Light Corporation are fitting up an installation at the Imperial Bank, Lothbury.—Messrs. Sharp & Kent, of Victoria Street, Westminster, have secured the contract for fitting up an installation in the new premises now approaching completion near Moorgate Street, for the Institute of Chartered Accountants.

Electrical Engineer for Dundee.—A meeting of the special committee appointed by the Dundee Gas Commission to draw up a short leet of applicants for the post of resident electrical engineer was held last week. It was reported that 53 applications had been received for the appointment. These were carefully gone over by the committee, and it was agreed to recommend the following four gentlemen as a short leet:—Mr. W. H. Brownlee, Glasgow; Mr. A. B. Gill, 36, Parliament Street, Westminster; Mr. A. Faraday Proctor, Newcastle-on-Tyne; and Mr. Charles Yeaman, 44, Heman Street, Princes Park, Liverpool.

United Asbestos Company, Limited.—The Lords of the Admiralty have again awarded the United Asbestos Company, Limited, the contract for the supply of all asbestos goods required in the Royal Navy during the ensuing 12 months, the principal articles being "Victor" block packing, "Victor" metallic packing, and hard spun yarn packing for glands; "Victor" metallic sheeting, tape, rings, ovals, &c., for steam and hydraulic joints; asbestos millboard, asbestos tape, covering for steam pipes, &c.

Catalogues.—A new catalogue of electrical testing instruments has been prepared by Mr. Robert W. Paul, of Hatton Garden. Prices and detailed information are given therein regarding the firm's manufacture of standard coils and boxes, galvanometers, keys, electrometers, condensers and batteries. Some of the instruments are clearly illustrated. Speaking generally, the list has been neatly got up, and is well printed.

Evans, Stewart, Palmer & Co.—Messrs. Evans, Stewart, Palmer & Co. have just commenced fitting up an installation for Messrs. Westley, Richards & Co., Limited, gunmakers and contractors to Her Majesty's Board of Ordinance, 178, New Bond Street, W. Orders in the firm's electric bell and fire and burglar alarm department, for the West End, are unusually numerous.

Electric Lighting of Police Buildings.—The new police buildings, including two courts now being built at South Shields, are to be lighted by electricity. The contract, which provides for upwards of 200 incandescent lamps of various candle-powers, has been given to Mr. T. Harding Churton, of 5, South Parade, Leeds.

Glasgow Electric Lighting.—The Corporation of Glasgow have accepted the tender of the Brush Electrical Engineering Company, Limited, for the supply and erection of series arc dynamo machines and lamps for public lighting, in accordance with the specifications drawn up by Prof. Kennedy.

The Antwerp Telephone and Electrical Works.—Under this title an establishment has been started, at Antwerp, for the manufacture of all kinds of electrical instruments, especially those required for telephonic purposes, and it is intended to open a branch house in London shortly.

Johnson & Phillips.—The Chatham, Rochester, and District Electric Lighting Company, Limited, have accepted the tender of Messrs. Johnson & Phillips for the laying of underground mains in Chatham on the Brooks system of oil insulation.

CITY NOTES.

City and South London Railway Company.

THE sixteenth ordinary general meeting, being the half-yearly meeting, was held on Friday last at Winchester House, Old Broad Street, Mr. G. Grey Mott presiding.

The SECRETARY (Mr. W. F. Knight) read the notice convening the meeting.

The CHAIRMAN said he presumed they would take the report as read. It was his duty to move that the report and accounts, as presented to the meeting, be received and adopted. It was satisfactory that during the past half-year the steady increase of traffic had continued, and that the position of the company had decidedly improved. In the first place the number of passengers had increased during the period from 2,412,000 in 1891, to 2,813,000 in the last half-year. That showed an increase of about 400,000 passengers; but in addition to that, they had in the half-year the season ticket holders, which were estimated at about 100,000 additional, therefore, in round numbers, they might say that there had been an increase in the half-year of about half a million of passengers over the corresponding period last year. When they considered that last year was the first half-year of the opening of the line, and that there was naturally a very large rush of people who came to see the line simply from curiosity, and not from any intention to use it regularly, and also that during that half-year they had the large omnibus strike in London, which added to the receipts of the company at the time, it was satisfactory to think that they had not only carried the half million additional passengers, but that they had carried them in excess of those artificial sources of receipts. The progress of the line was not simply in connection with the increase of the passengers. They had increased receipts from other sources, in the shape of rents and other small items, and they had the satisfactory fact that their expenses had decreased. The percentage of expenses for the three half-years were as follows: In the first half-year they amounted to 79 per cent. of the receipts; in the second half-year that they were opened they were reduced to 76 per cent., and in the half-year just closed they had been further reduced to 70 per cent. He hoped that would go steadily on, that figure decreasing half-year by half-year, until they came down to a really satisfactory figure. Of course, in a small concern like the City and South London, in its early history the percentage of expenses must be very great. They would see that during the three half-years with which they had had experience they had steadily increased their receipts, and had steadily decreased their expenditure. The first half-year, the net earnings of the line were sufficient to pay its expenses, and pay the whole of their debenture interest; the second half-year, there was sufficient to pay the expenses, the debenture interest, the full dividend on the preference shares, and to carry forward a moderate balance. The last half-year there had been sufficient to pay debenture interest, the full dividend on the preference shares, ½ per cent. dividend on the ordinary share capital, and to carry forward a balance larger than they brought into the half-year. Those were all symptoms of a very steady and satisfactory progress. Of course, they wished that that progress was more rapid; but, at the same time, they must recollect that all sound businesses had to be worked up by slow degrees, and were matters of hard work and good management; yet, when so worked up, they were far more permanent and solid than those successes which were achieved rapidly, and which too often diminished rapidly afterwards in the same way. He believed there was no better or more permanent mode in which capital could be invested in this country than in a purely passenger line in the metropolis, if the cost of that line was commensurate with the probable income to be derived from it. He believed their cost of the City and South London line would be found in the future to be so commensurate, and that the future dividends of that line when they had steadily accumulated, as he believed they would from half-year to half-year, would arrive at a figure that would satisfy all their shareholders. He would next call their attention to the accounts in more detail. During the half-year, as regards the capital account, they had issued of preference £30,904, and in debentures £3,300, making a total of £34,204. They had received several surplus amounts of some £5,800, making the total receipts on capital accounts £40,004. That had cleared off a great many of the liabilities which had been standing at the debit of capital account, but there was still a debit of some £22,000 remaining there against it, which they hoped in the next half-year they would be able to clear off, especially the portion which is now bearing interest. Turning to the revenue account, No. 9, they would see that the receipts from the passengers and parcels amounted to £20,940, and from rents and other small items £580, making total receipts of £21,520 in the half-year against £19,637 in the corresponding half-year in 1891, showing an increase for the half-year of £1,883. On the other hand, the expenses of maintenance had increased by the sum of £52; the locomotive expenses had decreased £552; the carriage and wagon repairs had increased £63; traffic expenses had decreased £484; the general charges had increased £78; rates and taxes had increased £250, law charges had increased £34, and compensations had increased £134, making a total net decrease of £424. The result of the half-year's net working has shown that there was a profit of £6,422, against £4,116 in the corresponding period last year. The interest on debentures absorbed £4,317, leaving £3,031 available for dividend. After paying full dividend of 5 per cent on the preference shares, and ½ per cent. on the ordinary stock, there remained a balance of £983 to be carried forward in place of the sum of £850 brought into the account from the previous half-year. The amount at the credit of the profit and loss account would have been sufficient to have paid a dividend of ¾ instead of ½ per cent. but the directors thought it much more in the interest of the company that they should carry forward a larger balance, and altogether be in a stronger position financially, rather than pay the last penny, comparatively, that they had in the exchequer. One of the most interesting features in these accounts was always the question of their locomotive expenses. They still adhered to the word "locomotive" expenses; although they were not like the old locomotives, they were locomotives with an electric force. Their expenses per train per mile for the first half-year they were open were in tolerably round figures, 9d. per train mile; the second half-year they were reduced to 7·9 pence per train mile, and this half-year, although there was no increase of the train mileage, it was practically the same as it was the previous half-year, namely, 7·7 pence per train mile. Now, in comparing those figures with those of an ordinary steam railway, they must always recollect that in addition to the work of an ordinary line, they had the lift and the hydraulic apparatus for taking the passengers to and from the surface to the trains, and that made a very considerable difference in the cost of the working of their railway; and although it did not affect the locomotive expenses, it affected their general expenses to a very fair and considerable percentage; but still, with all that, they were enabled to compare favourably on all points with the ordinary steam railways of the country. The locomotive expenses, as he had said, were 7·7d. per train mile, and the ordinary locomotive expenses on the large English railways when they got their coal at the pit's mouth without any carriage upon it, came out at the present moment at about 9d., or a trifle over, per train mile. Where they had to pay carriage upon their coal, such as Southern lines, South of the Thames, where there were no collieries upon their lines, then it was increased to 10d., and from that to 10½d. per train mile. Of course, they in their case had not only to pay the carriage on the coal from the colliery, but had also to pay the cartage of the coal from the station to the depôt: that increased the cost of their coal, which was a very large item in their locomotive charges, considerably above that of any of the other railways, but notwithstanding all those additional charges, they would see that they stood at 7·7d. against 9d. to 9½d. per train mile. On the other side their steam friends told them that they were not capable of carrying so much traffic, which was perfectly true, but at the same time, they were capable of carrying a very large traffic, and the number of passengers per train was slowly and steadily augmenting every half-year. For the three half-years, in the first it was 45, in the second 46, and in the last it was 47 per train run. The question of fares charged was also a rather interesting one. They would remember when they began they charged an uniform fare, which it was found necessary or expedient to alter from time to time to suit the exigencies of traffic. The result was for the first half-year, before they altered it, they received 1·90d. for each passenger. In the next half-year that was reduced to 1·70d., and in the last half-year there had been a slight increase, and it was 1·73d. per passenger, that was about 1¾d. The result of those alterations apparently had been, as far as they could judge, satisfactory, because, although they were actually earning less per passenger than they did the corresponding half-year last year, they had a considerable increase in the total receipts. Turning to the report, in paragraph 5, they would see that theirs, being the only installation of the kind in the country, if not in the world, naturally there had been a great deal of curiosity and interest to see their generating station, and to see by what means the power was produced. That was somewhat inconvenient to them, because it interfered with the people employed at the works, and it gave a good deal of trouble to those who desired to see the works, because they had to make special application to get permission. They therefore thought it better to put up a small gallery in the engine-house apart from the people employed there, and to allow the public to have access to that gallery, where they could see the whole of the engines at work on payment of a small sum. He was glad that had been approved generally, and they had a number of people there every day, thus adding funds to the company. Paragraph 6 dealt with a Joint Committee of both Houses of Parliament that was appointed to consider and report the best method of dealing with the various electric and cable railway schemes in the metropolis that were proposed last session for the sanction of Parliament. That Committee reported most favourably as regards those schemes, both as to construction and to their working by electricity, and they had suggested that in future it would be desirable to give to any schemes easements under property, where they did not do any damage, at a small cost without the necessity, as they have had to do hitherto, of following the line of the streets. No doubt if that was approved by Parliament, and carried out, it would give much more direct and better lines than would otherwise be constructed, and diminish the cost of the extension of lines of this kind. Six years ago no steps had been taken even to start the construction of this line. It was a little more than five years ago since the idea first entered the speaker's mind that they might work this railway by electricity in place of the cable system, for which it was originally intended, and it seemed extraordinary that in that short space of time such an entire revolution should have taken place in the views of people travelling in the metropolis; that in five years' time they had applications for numbers of railways in the metropolis, and, strange to say, all of them proposed to be worked by electricity. If they had not yet got an adequate return financially for their money, they would at all events have the satisfaction of knowing that they had in-

augurated a new system of locomotion, which was destined, he believed, to have a far-reaching expansion, and would add to the comfort and prosperity of the inhabitants of this country very largely. They would remember that they introduced a Bill for extending their line to Islington, and getting rid of the inclines under the river. That Bill was introduced into Parliament with the other Bills, but owing to the dissolution, only two of them were actually passed. He did not suppose anything further would be done with them until the early part of next year. During the past half-year they had been carefully consolidating their machinery at the generating station. They had got the new engines and the new dynamo at work, and they were now in a position to meet every possible contingency that was likely to happen on this line, and, further than that, to work a very large extension of the line without any material addition to their plant. They wanted, as far as possible, to meet the growing traffic by additional trains; but as he had explained to them before, one of their difficulties was the want of siding accommodation. They had hoped to have gone on with that work during the past half-year, but it was delayed for various reasons. They hoped within a few weeks now to start those works and sidings, which, when completed, would be of very great advantage to the working of the line. The next question arising on paragraph 9 of the report was with reference to the debentures. Their debentures were first issued as terminable debentures. They felt at the time they issued them that it would be wrong to burden the line with a permanent 5 per cent., and he thought they were wise in that decision. They therefore issued them for periods varying from 5 to 10 years, and some of them would become due in the course of the next year. They proposed to ask their sanction now for the creation of permanent debenture stock. Their idea was to issue that stock at the same rate as most of the companies had issued theirs; that was a 4 per cent. stock, but, of course, the price of that stock at the time of its issue would determine the rate of interest which they would actually pay. They would do their best to get it issued on the very best terms as regards premium, and they think it probable that a good many of the existing debenture holders may in view of the probability of that stock rising to a considerable premium be disposed to convert their debentures upon terms to be arranged before they expire. In any case, they would be in a position to pay those off and supplement them with the debenture stock, the interest upon which would be not more than 4 per cent., and they hoped something like 3½ per cent., or perhaps less. If the interest was reduced to 4 per cent. they would save some £2,000 a year, or even £2,500, which was an important item in a small concern of that kind. He did not know that he had anything further to say beyond the fact that he looked forward personally with great satisfaction and hope to the future of this line. He thought if they all worked together they would be able to make it one of the most satisfactory railways, both financially and for comfort and convenience of the public that had ever been carried out in this country. The line, as a Metropolitan line, was certainly, even at the present time, unequalled. Their first endeavour would naturally be to get rid of the frequent breakdowns that interfered very much with the traffic. He was happy to say they were now events of very rare occurrence, and he hoped the time would come when they will be almost unheard of.

Mr. S. HANBURY seconded the resolution, which, after some discussion, was unanimously agreed to.

The CHAIRMAN next moved, "That the dividend on the 5 per cent. perpetual preference shares be paid in full for the past half-year," and "That a dividend at the rate of ½ per cent. per annum be paid on the ordinary shares of the company."

Mr. C. S. GRENFELL seconded the resolutions, which were unanimously adopted.

On the motion of Mr. MIDDLETON, Mr. James L. Oliver was appointed an auditor in place of Major Kitson, deceased.

The meeting having been made special,

The CHAIRMAN moved, "That the directors be and are hereby authorised to raise the money now owing by the company on mortgage or bond, or which they may from time to time have power to raise on mortgage or bond, by the creation and issue of debenture stock at such times and in such amounts, and on such terms and conditions as the directors may think fit."

Mr. S. B. STEWARD seconded the motion, which was carried.

The CHAIRMAN further moved, "That the directors be and are hereby authorised to issue a further 5,000 of the preference shares created by the resolution dated June 30th, 1891, in such amounts and at such times, and on such terms and conditions as they think fit." He said there was no intention on the part of the board to issue one single share more than was absolutely necessary.

The resolution was seconded by Mr. HANBURY and passed, after some remarks had been made by Mr. Court (a large shareholder.)

A vote of thanks to the chairman, directors, and officials of the company terminated the proceedings.

Halifax and Bermuda Cable Company, Limited.

THE third annual meeting of the above company was held at the offices of the company, 33, Old Broad-street, on Monday last. The following report was presented by the chairman:—

"The directors beg to submit to the shareholders the duly audited statements of accounts for the year ending 30th June, 1892. The result of the working is a profit of £1,261 14s. 2d., to which has to be added the balance brought forward from last year of £420 5s. 5d., making the sum now to the credit of revenue £1,681 19s. 7d. The cable receipts in the past year were £3,915 13s. 3d., as compared with £4,018 9s. 4d. in the preceding year. Notwithstanding this slight decrease the directors regard the result as quite satisfactory, as in 1890-1 there were exceptional sources of traffic. At the same time the directors have been able to effect further economies, so that the working expenses as shown in abstracts A and B are £609 10s. 3d. below the totals of the previous year. It is further subject for congratulation that all the outstanding difficulties in connection with the foundation of the company have been brought to a satisfactory conclusion. The claims of the Construction Company have been discharged, all open matters with the International Cable Company, Limited, have been finally adjusted, and the very heavy legal charges have been met. The result of these adjustments is that £10,153 16s. 10d. has been expended beyond the outlays chargeable to capital account. This has in part been met out of the revenue account, but, to the extent of £6,000, money has been provided on advantageous conditions by the new friends of the company. The company's cable has throughout the year worked with complete efficiency, and its present electrical condition is excellent. Under the articles of association the two senior directors should retire. These are Sir Alexander Armstrong, K.C.B., and L. H. Isaacs, Esq., but these gentlemen do not seek re-election, and on the ground of economy it is not proposed to at present fill the vacancies thus created. The auditors, Messrs Gribbon, Ingram, and Holroyd, retire in accordance with the articles of association, and they offer themselves for re-election."

The report and accounts, we are informed, were unanimously adopted, and the auditors were re-elected.

The Kensington Court Electric Lighting Company, Limited.

AT extraordinary general meetings of the above company, held at 1, Great George Street, on the 21st July and 5th August, 1892, the following special resolution was duly confirmed:—

"That the company be wound up voluntarily under the provisions in that behalf of the Companies Acts, 1862 and 1867; and that Robert Steuart Erskine, of 148, Brompton-road, in the county of London, gentleman, be and he is appointed liquidator for the purpose of such winding up."

Telephone Company of Ireland.—It is stated in the directors' report, just issued, that the business of the company continues to develop steadily. The number of wires, exchange and private, on December 31st last, was 1,538, being an increase of 65 for the year. The balance standing to the credit of the net revenue account amounts to £5,362 10s. 11d., which the directors propose to divide as follows: to the credit of the reserve fund, £369 19s. 10d., carrying forward the balance. The supplementary accounts to June 30th, 1892, show that the balance to credit of net revenue at that date is sufficient, not only to pay the whole of the preference dividend, but to leave a substantial sum for division among the ordinary shareholders.

The Pioneer Telephone Company, Limited.—An extraordinary general meeting of the Pioneer Telephone Company, Limited, is to be held at Winchester House (Hall 174), Old Broad Street, E.C., at 2.30 p.m., on Tuesday, August 16th, 1892, for the purpose of considering, and, if thought fit, passing the following resolution: "That the company be wound up voluntarily." Should the above resolution be passed by the required majority, it will be submitted to a subsequent extraordinary general meeting for confirmation as a special resolution. The meeting will also be asked to pass a resolution fixing the amount to be paid to the directors by way of remuneration for their services.

Sheffield Telephone Exchange and Electric Light Company, Limited.—At extraordinary meetings of this company, held on July 18th and August 2nd, the following resolution was agreed to:—"That it is expedient to reconstruct the company, and accordingly that the company be wound up voluntarily; and that Thomas George Shuttleworth, of Sheffield, chartered accountant, and William Johnson, of Sheffield, the secretary of the company, be and they are hereby appointed liquidators for the purposes of such winding up."

Cuba Submarine Telegraph.—A dividend at the rate of 8 per cent. per annum is recommended by the board for the first half of the current year.

The Electric Tramcar Syndicate, Limited.—At two extraordinary general meetings of this company it was decided "that the company be wound up voluntarily."

TRAFFIC RECEIPTS.

The City and South London Railway Company. The receipts for the week ending August 7th, 1892, amounted to £919; corresponding month, 1891, £822, increase £97; total receipts to date for half-year, £4,708; corresponding period, 1891, £4,299; increase £404.

The Great Northern Telegraph Company. Receipts in July 1892, were £23,300. 1st January—31st July, 1892, £152,000; corresponding months, 1891, £165,800; corresponding months, 1890, £156,000.

The Western and Brazilian Telegraph Company, Limited. The receipts for the week ending August 5th, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited, amounted to £2,771.

A CONTRIBUTION TO OUR KNOWLEDGE OF THE RHUMKORFF COIL DISCHARGE.

THE methods and results obtained by Nyland, Rood, Cazin, Mayer and Holtz in their investigations on the nature and duration of induction currents, have been duly chronicled from time to time, and are well known, but it has remained for T. Moll to make a new departure in the examination of the discharge of the Rhumkorff coil. This German physicist has enlisted photography into his service. An image of the discharge spark was projected by means of a small concave mirror upon a rapidly revolving circular disc which carried a sheet of sensitive paper. The time of closing the primary current and the velocity of rotation of the disc were registered on a revolving cylinder which also received the trace of a vibrating tuning fork. A large induction coil was used in these experiments, its length being 57 cm., and its diameter 21 cm. The electrodes furnishing the spark were connected with a Leyden jar, having an interior coating of about 772 sq. cm., and the external resistance in the secondary circuit was always the same and quite small.

Moll obtained a large series of photographs by this method, and he was enabled, owing to the conditions under which they were taken, by a study of them, to ascertain the entire duration of the discharge, the intervals of time between the partial discharges and their mean. This was undertaken for sparks of various lengths, for primary currents of different strengths, for various capacities of the Leyden jar, and for different forms of the electrodes, with the result that a considerable addition has been made to our knowledge of the discharge of the Rhumkorff coil. The following are the chief results:

As the length of the spark increases the total duration of the discharge diminishes; and this is also the case with the number of partial sparks composing it, but the interval of time between these partial sparks increases. For long sparks the mean interval of time, u, between the partial sparks is proportional to the square root of the spark length, $\sqrt{l}$. But for short sparks, u appears to be greater than this law would demand; also the time-intervals between the two first partial discharges increase, as it appears, a little more rapidly than $\sqrt{l}$. When the length of the spark was made less than 0·75 mm., Moll found that sparks were produced even on completing the primary circuit, but in this case the number of the partial discharges was much smaller, and their mean distance apart greater, than when the circuit was broken.

When the strength of the primary current is diminished, the number of the partial discharges and the total duration are quickly curtailed, but the mean time-interval of the partial discharges stands in an inverse ratio to the current strength. This applies also to the value of the first time-interval.

As the capacity of the Leyden jar is increased, the discharge consists of a series of partial sparks with increasing time-intervals. When the capacity is diminished, the number of the partial sparks is increased, and the discharge finally appears partly continuous. Since this "continuous" light did not sufficiently affect the sensitive paper, Moll made a number of direct experiments with the revolving mirror, and ascertained that the "aureole" was preceded by a few, and followed by a greater number of, partial sparks. As the capacity was made smaller, the number of these sparks was diminished, until finally the "aureole" formed the greatest part of the discharge. As long as the discharge was entirely disruptive, a diminution of the capacity diminished the time-interval between the partial sparks, but increased the total duration. For short sparks, however, the total duration appears to approach a constant quantity, and to be independent of the capacity; it is about 0·023 second.

When the investigator used more pointed electrodes, he observed that the entire duration increased. Also the number of the partial sparks, but the mean time-interval between them was diminished. When the electrodes were made very sharp, completion of the primary current produced sparks, but their number was small. All the experiments show that the time-interval between the partial sparks increases towards the end of the discharge, the last interval often being twice as great as its predecessor. Moll expresses the relation of the time-intervals, reckoning from the first partial spark by an exponential function, and the agreement between calculation and observation is very good if the last three time-intervals are neglected.

The results obtained in this investigation agree very well with the observations of Rood, but differ from those obtained by others to a degree that is not insignificant. It seems that the nature of the discharge appears to be a little altered by the modes of observation which they employed, for example, in the experiments of Nyland and Mayer, the spark struck through a sheet of paper, and in those of Holtz, the spark itself was in rotation. From such defects the methods used by Rood and Moll appear to be free.

Moll allowed the sparks to fall upon a rotating disc of paper, the electrodes on either side of this paper being at slightly different distances from the centre of the disc. He observed that the holes made by the sparks were always opposite one of these electrodes, consequently all the sparks have the same direction. Starting from this fact, he endeavours to explain the phenomena of the discharge by the assumption that the electricity cannot flow with sufficient rapidity to the electrodes, and that partial sparks are produced as soon as the difference of potential has reached a certain value, dependent on the distance of the electrodes apart, &c. This account is abstracted from the American *Journal of Science*, but it is given more fully in the *Beiblätter z. d. Ann. der Phys. u. Chem.*, xv. It may be added that the deductions which may by the help of known facts be drawn from Moll's results, agree, as a whole, very well with results previously found experimentally.

THE ELECTRIC LIGHTING OF BRUSSELS.

II.

ON the resumption of the discussion on the above subject by the Brussels Communal Council on Thursday of last week, M. Janssens opened the proceedings by stating that he did not lay claim to any technical competence: he limited himself to relying on the opinions of competent men. M. Bède had sounded the praises of accumulators from an economical point of view. M. Wybauw, the city's engineer, answered that, with accumulators, 25 per cent. of the total produce would be lost. In the earlier years they might gain by using accumulators; but afterwards the situation would entirely change. Messrs. Crompton had themselves praised the system presented by the College. The batteries of accumulators required incessant and multiplied care, without which the apparatus rapidly deteriorated. The second point was canalisation. M. Bède varied strangely, according to the ideas of Mr. Preece, who himself changed often enough. The vouchers furnished by the India-Rubber, Gutta-Percha and Telegraph Works Company, and by Mr. Crompton, gave every satisfaction on the cable subject; according to other information, the cables of the India-Rubber, Gutta-Percha and Telegraph Works Company were superior to the cables employed by the Schuckert Company. M. Bède had also criticised the drawing in boxes. Everything was bad and provisional, to him, in the scheme which they proposed to the Council. The engineers whom he criticised, however, were those connected with one of the most powerful companies in the world. They had calculated that for the first establishment the system of the India-Rubber, Gutta-Percha and Telegraph Works Company would cost 15 per cent. less than that of the Schuckert Company. The third point was expense. But M. Bède, when he referred to the India-Rubber, Gutta-Percha and Telegraph Works Company, only touched upon the nominal capacity of their machinery, while, in speaking of the Schuckert Company, he calculated according to the maximum of their machinery. He said that the Schuckert canalisation would cost 600,000 francs; that sum was far too low. They must calculate that the canalisation would cost 1,200,000 francs at least. Moreover, if, on that question, they consulted 20 technicists, they would have 20 different opinions. The experts had estimated the different systems; they had not contented themselves with calculating which would cost the least, as in an ordinary case, because the most important factor there was the facility of the progressive increase of the installation. With the India-Rubber, Gutta-Percha and Telegraph Works Company the network could be extended very commodiously, and that

was the reason which had determined the preference of their experts, and not the consideration of cheapness. The project which they proposed had been abused on account of the cost of the first establishment. Those reproaches were not well founded; for the canalisation would not exceed 1,600,000 francs, and the route of the India-Rubber, Gutta-Percha and Telegraph Works Company was wiser and more prudent than that of the Schuckert Company. M. Bède claimed new experts and a fresh inquiry; he had evidently not wished to suspect the integrity of the city's three engineers, MM. Wybauw, von Vloten and Dierman, all three men of experience, and all three with a knowledge of English and German. The College thanked them and accepted their report, but it did not accept the criticisms formulated against them. M. Janssens concluded by inviting the meeting to vote the conclusions of the College. M. Depaire said he was a partisan of accumulators, in view of a regular production of the light. He praised experience in the matter of electricity, and quoted the installations of the Schuckert firms at Hamburg, Düsseldorf, Munich, &c. The India-Rubber, Gutta-Percha and Telegraph Works Company had made comparatively no city installations. Touching on the financial portion of the subject, he asked if a loan was to be applied for, whereupon he was answered in the negative. M. Richald said he would propose it himself. M. Depaire recalled the enormous expenses which the distribution of water had entailed. He did not think the subject of lighting had been sufficiently studied. He proposed a resolution, having for its object the postponement of the examination of the India-Rubber, Gutta-Percha and Telegraph Works Company's scheme. M. Bède said he would not return to the accumulator questions, since there were divergent opinions. He was reproached, he said, for following Mr. Preece, but he could not rely upon a better authority. He did not say that the cables of the India-Rubber, Gutta-Percha and Telegraph Works Company were bad, quite the contrary; he had said the cables were very dear, and that he preferred the iron armoured cables of Schuckert, Siemens, &c., tested by more than 30 years' use. He then passed to the question of canalisation, and defended his original calculations; he believed that, placed in tubes, the Silvertown Company's cables would not last very long. He asked that no adjudication should be made till they had complete plans and definite estimates; but, he said, if the discussion were circumscribed between the India-Rubber, Gutta-Percha and Telegraph Works Company and the Schuckert firm, it was the latter which should win, since it asked a million less, and had proved its competency in the great cities of Europe. The India-Rubber, Gutta-Percha and Telegraph Works Company offered less practical guarantees; but, under present conditions, they should appoint a special committee to study the schemes of the Silvertown company and the Schuckert firm. M. Buls then briefly replied to M. Depaire, who, he said, had forgotten that in the system which they proposed they had introduced sufficient accumulators to ensure the regularity of the light. The India-Rubber, Gutta-Percha and Telegraph Works Company, it had been said, had not made installations in towns; but it had carried out important installations, and there was the principle; the Schuckert installations were of too recent a date to permit of an argument being drawn from them.

The subject is still under consideration, although the Silvertown company is now assured of the contract.

THE CURRENT THAT CURES.

By H. NEWMAN LAWRENCE, M.I.E.E.

ELECTRICIANS are often led to look slightingly on that branch of applied electricity which deals with its uses in medicine, and not without a fair amount of reason. The medical profession, after many long years of neglect and suspicion, are still barely tolerant to the subject. To so marked an extent is this the case, that an eminent member of the profession, Dr. Thomas Keith, wrote recently as follows:—"Electricity, in any form, when applied to the cure of disease, is set down as pure quackery by many medical men, simply because they know nothing about it, and won't take the trouble to learn for themselves what, to many, is rather a hard study." These are strong words—much stronger than it becomes me to use; but anyone who takes the trouble to investigate the matter, will not consider them unjustifiable. On the other side, we find ignorant and unprincipled people claiming all sorts of impossibilities to be achieved by the aid of various so-called "electric" absurdities, which, for the most part, outrage all the principles of electrical science, and from which electricians turn in disgust. It matters not to the sellers of these wonders whether they be really electric or non-electric, so long as they can use the word "electric" as a charm wherewith to conjure golden tribute from the pockets of the credulous public into their own coffers.

It will be my endeavour in these articles to show that there is a great deal more of practical value and scientific truth in medical electricity than the indifference of the medical profession, and the blatant absurdities of advertising quacks, would lead us to suppose. This matter concerns electricians very closely, and it behoves them to do what they can to prevent a beneficent branch of applied electricity being starved out by the suspicious attitude of the former, or brought into ridicule and contempt by the latter.

In considering the subject, it will perhaps be well to deal with it in three sections: 1. What does the current cure? 2. What form of current cures; and 3. How current cures.

1st. What does the current cure? To find a complete answer to this question is not easy, as, owing to the position of the medical profession above referred to, cases are seldom treated by electricity alone. Other methods are often combined with it, and the cases for which electrical treatment is prescribed are often in the last and worst stages of disease. I have several times received patients from medical men with the remark that, as every other remedy had been tried thereon without effect, it was *now* thought desirable to try electricity. That, in spite of these difficulties, electricity has proved itself a very valuable curative agent there is ample evidence. Published and trustworthy records of cures by means of electricity are to be found in all the chief countries of Europe, in America, and also, though to a much smaller extent, in our own country. Wherever medical men have taken up the subject in a worthy manner, and practised it scientifically, they have found the results to more than justify its adoption.

A full and critical examination of these records as they appear in the various publications of the different countries, would take too much space, and perhaps be somewhat out of place in these columns, but a fair idea of the extent of the curative and palliative effects of electric currents may be obtained by a brief reference to one or two standard works.

In Dr. W. Erb's splendid work on electro-therapeutics, we find particulars given for the electrical treatment of a wide range of diseases, in all of which electricity has been proved either a cure or a palliative. He divides them into classes as follows:—1. Diseases of the brain. 2. Diseases of the spinal cord. 3. Diseases of the peripheral nerves. 4. Paralysis and atrophy. 5. Painful neuralgic affections. 6. Spasm and contractions. 7. Anæsthesia. 8. Diseases of the cervical sympathetic. 9. General neuroses. 10. Diseases of the organs of special sense. 11. Diseases of the organs of motion and of the digestive apparatus. 12. Diseases of the genital and urinary organs. In classes 1 and 2, cures are recorded, but the effect of electric treatment seems to be regarded as mainly palliative. In all the other classes several cures are quoted, mostly from the author's own experience, but partly from that of others, on whose records he could rely. If, then, Erb's statements are to be accepted, and few, indeed, would attempt to deny them, electricity has a powerful curative effect upon a very large number of the diseases common to man. A moment's consideration of the classes named by him shows the extent of the ground covered, without going into the detail of naming the numerous diseases of which each class is composed. Such is the testimony of the great German electro-therapeutist, whose views and teachings are clearly traceable in the works and utterances of the best English writers on the subject.

America gives also strong evidence of the curative effect of electricity, though the books published by her electro-specialists fall far short of Erb's great work in sound science and general utility. The works of Beard and Rockwell, of Leibeg and Rohé, of Massey and of Wellington Adams,

among others, show records of cures in many of the diseases named by Erb, but they also give evidence of the great value electricity possesses in the diseases of women. In nearly all the thousand and one ailments, the weaker sex are specially liable to, electricity when properly applied, has proved itself far and away the safest, most reliable, and, therefore, the best curative agent at present known. The initiative, however, in this last-named branch of electro-therapeutics, seems to have come from France, where such masters in medicine as Apostoli and Charcot have made the subject their own, and given overwhelming evidence of the efficacy of the current.

In our own country we find much confirmatory evidence, but little that is new. Here the medical profession seem well content to follow in old and worn tracks, leaving initiative, for the most part, to their brethren in other countries.

Their published utterances on electro-therapeutics, with few exceptions, leave much to be desired, but their evidence of the value of electric currents in a large number of diseases is decided. Erb and Apostoli are the leaders they mostly follow, so there is no need to further indicate the classes of diseases upon which their evidence is confirmatory.

(*To be continued.*)

THE ELECTRIC LIGHTING OF FRANKFORT.

[FROM OUR OWN CORRESPONDENT.]

THE project of erecting electric works at Frankfort-on-Main has interested this city and electrotechnicists in general for years, on account of the question of systems, which comes here strongly to the front, and it has at last been carried a step forwards. The experts interested with the elaboration of a new, final project, Oscar von Miller and Lindley, "director of deep structures"—an office not very intelligible—have completed their labours and submitted the result in a very carefully and circumspectly elaborate report and opinion.

In these documents, in view of the projects which have been handed in, three systems are discussed, namely—1, alternating current transformers; 2, accumulators with direct distribution of current; and 3, accumulators with alternating current and continuous current converters.

After a general consideration follow the numerical tables, extracted from the various tenders:—I., costs of installation, and II., rentability, each for the two groups—1st, construction (for the part to be completed first), and 2nd, construction, the subsequent extension, the former for 25,000 and the latter for 67,000 glow-lamps of 50 watts each, burning simultaneously.

COSTS OF INSTALLATION. I.—ERECTION.

Comparative computation of outlay for the electric works, Frankfort-on-Main, according to different systems of distribution for 21,000 *or* 25,000 *lamps burning simultaneously at* 50 *watts.*

Object.	Alternating currents.	Accumulators direct.	Accumulators with conversion.
	m.	m.	m.
1. Cost of land	227,000	284,500	354,000
2. Buildings	505,800	437,000	437,000
3. Secondary stations	19,800	206,000	232,000
4. Works for current	215,000	231,000	231,000
5. Boiler, pipes, &c., for feeding	180,000	137,500	137,500
6. Engines, apparatus, transformers	705,000	1,041,000	1,203,500
7. Cable net	716,000	1,717,000	945,500
8. Meters in houses	310,000	380,000	380,000
9. Sundries	123,400	137,000	146,000
Sum Total	3,996,000	4,635,000	4,097,000

The following table is for the simultaneous use of 67,000 lamps by the three systems.

Object.	Alternating currents.	Accumulators direct.	Accumulators with conversion.
	m.	m.	m.
Land	227,000	448,500	448,500
Buildings	746,706	621,200	621,200
Secondary stations	52,600	320,500	361,000
Street operations	578,000	652,000	642,000
Boilers, &c.	410,000	290,000	290,000
Machinery and apparatus, transformers, &c.	1,802,000	2,500,000	2,682,000
Cable net	1,900,600	5,231,700	2,639,300
Meters in houses	930,000	930,000	930,000
Sundries	266,000	338,100	295,000
Sum total	6,903,000	11,332,000	9,110,000

RENTABILITY (1 SCALE).

Comparative view of receipts and expenditure for the three systems above mentioned.

1. For alternating current transformers.

Receipts	706,000 m.
Expenditure	475,000 m.
Balance	231,000 m.

This sum corresponds to $7\frac{3}{4}$ per cent. on a capital expenditure of 2,996,000 or $11\frac{3}{4}$ per cent.

2. For accumulators with direct distribution.

Receipts	840,000 m.
Expenditure	656,000 m.
Balance	184,000 m.

This sum corresponds to about 4 per cent. on a capital of 4,685,000, or 8 per cent.

3. For accumulators with alternating current or continuous current conversion.

Receipts	840,000 m.
Expenditure	609,000 m.
Balance	231,000 m.

This sum represents about $5\frac{1}{2}$ per cent. on a capital of 4,097,000 or a general interest of $9\frac{1}{2}$ per cent.

Comparison of the same three systems on the larger scale.

1. Alternating current-transformers:

Receipts	1,695,000 m.
Expenditure	1,135,000 m.
Balance	560,000 m.

This represents 8 per cent. on an installation outlay of 6,903,000 at 8 per cent., or a total return of 12 per cent.

2. Accumulators with direct distribution:

Receipts	1,695,000 m.
Outlay	160,000 m.
Balance	8,500 m.

This balance represents $\frac{3}{4}$ per cent. on installation outlay of 11,332,000 or $4\frac{3}{4}$ per cent.

3. Accumulators, alternating continuous current conversion:

Receipts	1,695,000 m.
Outlay	1,420,000 m.
Balance	275,000 m.

representing 3 per cent. on installation capital of 9,110,000 francs or 7 per cent.

N.B. The sums of money are all given as marks = shillings.

Bristol Electric Lighting.—The inquiry by the Local Government Board, with reference to the application of the Bristol Town Council, to borrow £66,000 for the purpose of supplying the city with the electric light, will be held at the Council House on August 12th (to-day), the inspector being Mr. Rienzi Walton.

CHICAGO EXHIBITION.

SIR HENRY TRUEMAN WOOD, the Secretary to the Royal Commission on the Chicago Exhibition, 1893, has just issued a report on his visit to Chicago in June last. The following are his remarks regarding the electric lighting and motive power arrangements for the Exhibition:—

"ELECTRIC LIGHTING.

"I made inquiries as to the arrangements for electric lighting, and ascertained that a small amount both of arc and incandescent lighting is being retained for foreign exhibitors, and that if any English company desired to take this up on the terms which have already been published, they could do so. The main bulk of the electric lighting has been arranged for on a commercial basis with American firms. They have not yet got all the power required for running dynamos, and would be glad if English exhibitors could send one or two 500 horse-power engines for the purpose. These engines would be placed among the lower plant, and the space allotted for the purpose adjacent to the Machinery Hall.

"Such engines would have to be delivered free on the cars at Jackson Park. Foundations would be provided and the engines erected by the Executive. The cost of running would also be provided, including wages of engineer, who might, if preferred, be appointed by the exhibitors, but would be under the orders of the Executive. Engines on the same bed plate as dynamo would be quite acceptable. At the close of the Exhibition the engines would be dismantled and placed on the cars.

"Special arrangements are to be made for the lighting of the Electricity Building. In this, each foreign section can, if it chooses, light up its own space.

"It is proposed to allow exhibitors to furnish all the lighting plant as exhibits. Steam would be provided free, but no payment would be made. Exhibitors who require current or light, and who do not provide generators, would be charged a low rate. Mr. Hornsby, the chief of the electricity department, could not say what the rate would be, but it would be about cost price. The motors and generators would be placed among the power plant above referred to. Exhibitors would be expected to lay their own cables in the conduits, do their own wiring, provide lamps, &c. The generators, cables, &c., might be supplied by different exhibitors.

"Exhibitors generating current would be allowed to use as much light as they pleased for themselves. In addition to the light thus supplied, the building will be lighted by arc lamps. For this light there is to be no charge.

"MOTIVE POWER.

"Mr. Robinson, the superintendent of machinery, would be glad if an English exhibitor would supply an engine of about 300 or 400 horse-power, to drive one of the lines of shafting in the British and German court. The Germans propose to erect an engine, and this would drive the second line common to both courts. The conditions on which this engine would be accepted would be the same as those for engines for running dynamos."

NEW PATENTS—1892.

7404A. "Improvements in or relating to dynamo-electric machines and electric motors." S. H. SHORT. (Date claimed under patents rule 19, April 19th, 1892.) Dated July 25th.

13,507. "Conduits with insulators for underground conductors for the distribution of electricity." W. H. SCOTT. Dated July 25th.

13,541. "Improvements in the manufacture of continuous lengths of tube by electrolysis. F. E. ELMORE. Dated July 25th.

13,542. "An improvement in tanks or cells for electrolysis and like purposes." F. E. ELMORE and A. S. ELMORE. Dated July 25th.

13,543. "Improvements in electrical installations for producing alternating currents." SIEMENS BROS. & Co., LTD. (Communicated by Siemens & Halske, Germany.) Dated July 25th.

13,549. "Improvements in dynamo-electric machines." F. V. ANDERSEN. Dated July 25th. (*Complete.*)

13,557. "Improved system of electric traction for railway trains, tramways, and the like, and apparatus in connection therewith." W. P. THOMPSON. (Communicated by La Société Anonyme pour le travail electrique des métaux, France.) Dated July 25th.

13,559. "An improved telephonic plant for private and domestic use." J. CERPAUX. Dated July 25th. (*Complete.*)

13,562. "Improvements in and relating to electrical accumulators for secondary batteries." D. YOUNG. (Communicated by A. E. Colgate, United States.) Dated July 26th. (*Complete.*)

13,595. "Improvements in apparatus for varying the strength and direction of electric currents." J. A. EWING and C. G. LAMB. Dated July 26th.

13,618. "An improved thermostat." W. H. MUNNS. (Communicated by A. H. Brintnell, Canada.) Dated July 26th.

13,619. "Improvements relating to electrical fire-alarms and the like." W. H. MUNNS. (Communicated by A. H. Brintnell, Canada.) Dated July 26th.

13,639. "Improvements in acoustic telephones." A. L. SIMPSON. Dated July 26th. (*Complete.*)

13,648. "Improvements in electric railways." M. W. DEWEY. Dated July 26th. (*Complete.*)

13,678. "An electric combination contact bell push and pull." W. R. WEBB. Dated July 27th.

13,683. "Improvements in the method of and apparatus for starting electric motors." T. R. ANDREWS and T. PREECE. Dated July 27th.

13,685. "Improvements relating to the saturation or impregnation of organic fibrous and cellular matter with liquids by the aid of electricity, and to apparatus therefor." H. H. LAKE. (Communicated by G. A. Oncken, United States.) Dated July 27th.

13,694. "Improvements in alternate current transformers." W. C. JOHNSON and T. BOYDEN. Dated July 27th.

13,698. "Improvements in the treatment of mandrels for electrolytic deposit of metallic tubes." F. E. ELMORE and A. S. ELMORE. Dated July 27th.

13,702. "Organisation and arrangement of a telephonic news transmitter." T. PUSKAS. Dated July 27th.

13,718. "Improvements in conduits for electric mains, and in laying the same." H. L. DOULTON and C. E. MORRIS. Dated July 27th.

13,722. "A new or improved clutch or motor for the transmission of power." D. W. CARTER, S. S. FULLER, and J. B. PERRY. Dated July 27th. (*Complete.*)

13,763. "Improvements in incandescent electric lamps." J. B. LEE. Dated July 28th.

13,764. "Improvements in the construction of secondary batteries." J. B. LEE. Dated July 28th.

13,765. "Improvements in alternate current electro-dynamic machines." M. HUTIN and M. LEBLANC. Dated July 28th.

13,850. "Improvements in incandescent electric lamps, and in apparatus connected therewith." Sir C. S. FORBES. Dated July 29th.

13,854. "Improvements relating to the application of electricity in connection with chairs, known as "dental chairs," for carrying out dental and other surgical operations." C. F. ROWLEY. Dated July 29th.

13,856. "Improvements in electric bells." G. BINSWANGER and H. J. COATES. Dated July 30th.

13,879. "Improvements in telephone receivers." E. W. L. HARRISON and S. MURRAY. Dated July 30th.

13,888. "Improvements in means or apparatus for signalling, advertising, or exhibiting announcements by means of search lights, or other powerful lighting appliances." J. S. W. HODGES. Dated July 30th.

13,892. "Improvements in appliances for producing galvanic action for curative purposes." R. F. MANN, J. PURVIS, and A. R. BURMAN. Dated July 30th.

13,894. "Improvements in submarine telegraph cables." W. H. PREECE. Dated July 30th.

13,919. "Improvement in incandescent electric lamps." E. THOMSON. Dated July 30th. (*Complete.*)

13,920. "Improvements in methods of regulating electrically-driven mechanism, and apparatus for putting the same into operation." W. H. KNIGHT and W. B. POTTER. Dated July 30th. (*Complete.*)

ABSTRACTS OF PUBLISHED SPECIFICATIONS, 1891.

The Price of all Specifications (old and new) is now 8d. each.

105. "Improvements in lightning arresters for electric conductors." F. HASELWANDER. Dated January 2nd. Consists in causing the lightning to pass through a chamber containing explosive material, gas, water, or other liquid, the power resulting from the explosion or decomposition being used for diverting the lightning from the parts which require protection, and also for purposes of signalling the rupture. 3 claims.

1,176. "Improvements in brush holders for dynamo-electric machines and electric motors." F. M. NEWTON and T. HAWKINS. Dated January 22nd. Each brush is preferably carried by a clamp mounted to turn upon an insulated pin carried by the frame or holder whereby the two brushes are moved around the commutator. Against the clamp, or in some cases the brush itself, acts one end of a spring the other end of which is carried by the insulated pin. To this pin is fixed an arm or bracket through which works an adjusting screw by turning which the pressure of the spring upon the clamp or brush as the case may be and consequently the pressure of the brush upon the commutator can be adjusted as required. Upon a pin preferably carried by the insulated pin hereinbefore mentioned, and arranged at the opposite side of the clamp to that upon which the spring acts, is pivoted an adjustable stop provided with a handle and formed with two sides or surfaces, the distances of which from the axis of the pin are different and such that when the stop is turned into one position it will press against the clamp in opposition to the action of the spring and will hold the brush away from the commutator, and when turned into a second position, say at right angles to its first position, it will leave the clamp free and permit the same to assume a position, under the action of the spring, in which the brush will bear upon the commutator. 4 claims.

1,779. "Improvements in electro-motors and dynamos for use in mines and other places." W. HARTNELL. Dated January 31st. Consists in encasing the dynamo or motor in a wrought iron or cast iron box, which may be cylindrical, rectangular, or any convenient

shape, approximately air tight, and arranging the dynamo or motor so that the iron case forms the return magnetic circuit. 8 claims.

2,067. "Improvements in electrical transformers." C. BAUR and W. DIESELHORST. Dated February 4th. The inventors first make a length of flexible stranded rope of soft iron wire, and cover this with insulating material. On this as a core they place in several ways the primary and secondary wires required for the transformer. According to one arrangement, they wind in one layer, or in several layers, an insulated wire or other conductor over the insulating material of the core; they cover this again with insulating material, and on this they wind in one layer, or in several layers, another insulated conductor, which they also cover with insulating material. Either of the two conductors may be used as primary or as secondary, being suitably proportioned according to the purpose for which the transformer is required. 1 claim.

3,262. "An improvement in conductors for electrical glow lamps." E. A. GIMINGHAM. Dated February 23rd. A short piece of platinum wire is brazed or welded, electrically or otherwise, to a wire of cheaper metal such as iron, copper or nickel. Over this latter wire and over its junction with the platinum is passed a glass tube somewhat loosely fitting the wire, and the end of this tube, where it encloses the platinum, is hermetically sealed around the platinum. The glass sheathed wire is then passed through a hole of the bulb or globe, the glass of which is hermetically sealed to the glass of the sheath. 2 claims.

17,399. "Improvements in dynamo electric machines." E. T. GILLILAND. Dated October 13th. Consists in casting the field magnets and the supporting arms for the journal bearings for the armature all in one piece of iron, and in such manner as to permit the boring necessary to finish the machine ready for assembling to be done at one operation, and also to provide for the insertion of the armature and the coils of the field magnets into position in the frame. 15 claims.

17,652. "Improvements in carbons for electric arc lamps." H. H. LAKE. (Communicated from abroad by the Thomson-Houston International Electric Company, of America.) Dated October 15th. Consists in forming the carbon electrode or pencil as a flattened bar or prism thickest at the middle and becoming thinner towards the edges, said pencil having, however, the increased transverse area in cross section necessary to give the required length of service, and, in ordinary forms of arc lamp, approximately twice the area of the ordinary round carbon which would be employed on a circuit having a current of the same number of ampères. 6 claims.

CORRESPONDENCE.

Incandescent Lamp Manufacture and Tests.

In your "Notes" of July 29th, under the heading "Incandescent Lamp Manufacture," you seem to doubt the ability of English manufacturers being able to compete with Continental ones, because the latter have had eight years' longer experience. The natural consequence will be that English makers will look to the Continent to supply them with the necessary technical and practical guidance, so as to avoid the costly experiments during manufacture which you mention. As far as picking up this lost ground goes, there are, no doubt, others who like myself, were forced to leave off lamp making in England at the time of the Edison-Swan monopoly, and were compelled to seek similar positions on the Continent, in America, &c. These, and others, who have had continuous experience will naturally be attracted to England when the time comes that they are sought for.

Industries remarks about "15-penny burners," but at the present moment prices are even lower, and now my firm, and all the larger Continental factories are supplying 10-penny "burners," and there is no impossibility to prevent this price going lower. After making many and continuous practical trials of the lamps from at least a half-dozen Continental factories, I find that their quality is very good, and, most certainly, not inferior to the present English ones, and in several important points superior to them. Tables of life and efficiency tests of batches of lamps supplied by various Continental firms were published in the ELECTRICAL REVIEW of November, 1890. These tests were made at the Electrical Station of the Imperial and Continental Gas Company in Vienna, and show results in 1890 far superior to the most recent tests in 1892 of English and American lamps, as referred to in the ELECTRICAL REVIEW of July 29th last.

The condition of matters on the Continent is quite different to that in England and America, for here we are open to great competition, and the result has been that considerable improvements have been made since 1890. The American lamps tested at the Ohio University, and the English lamps tested at the Central Institute, conclusively show that such lamps are issued at a far higher rate in watts per C.P. than is the practice on the Continent. Comparing these latter tests with the old—above mentioned—1890 tests, it will be seen that even these old pattern Continental lamps were far superior to the English and American ones in both initial and average C.P. and in initial and average watts per C.P. during their life. The great questions always asked on the Continent are, what is the number of ampères your 16-C.P. lamp takes? and what is its life? Competition on these points has had the effect of gradually increasing the efficiency, and now the most common efficiency is 3 watts per C.P.; and we are constantly supplying an increasing number of 2½, 2 and 1½ watts per C.P. lamps.

In further reference to the article in the ELECTRICAL REVIEW of July 29th, I would remark that the tests made by Mr. Wirts were not made under the same conditions as pertains (as far as I can ascertain) in the different factories from which the various lamps were obtained. Mr. Wirts used a revolving method for measuring mean horizontal C.P., whereas the usual factory method is with the lamp fixed, having its plane at right angles to the photometer bar. This alone would give different results from the maker's rating.

I quite agree with Mr. Wirts's remarks that "a good lamp badly rated, will give inferior results to a poor lamp accurately rated." This is a vital point, indeed, but I do not consider that it is of great practical importance that a 16-C.P. lamp must have just 16 C.P., although it is a *sine quâ non* that they must have the same initial efficiencies or temperatures. With the most experienced eye, unaided by a photometer, it is almost impossible to discriminate the difference between two lamps, one having, say, 100 volts 16 C.P. at 3½ watts per C.P., and the other having 100 volts 14 C.P. at 3¼ watts per C.P., when both filaments and bulbs have the same length and shape. Under slightly modified conditions, the general public eye can be easily cheated (or misled) to the extent of not being able to discriminate the differences between a 12 and a 16-C.P. lamp, especially if the former be run at a slightly higher efficiency (or lighter colour). This is a difference of 25 per cent., but for practical purposes, the mean C.P. should be kept well within these limits, and should, of course, average 16 C.P., and always take exactly the same number of watts per actual C.P., irrespective of nominal C.P.

You consider that the production of a lamp which shall not vary much in its illuminating power during its life, is an object which is worth attaining at the expense of a slightly lower efficiency. This is simply a question of "how much lower you would allow the efficiency to fall?" If a good lamp were run initially at 4½ or 5 watts per C.P., there would not be much complaint as to rapid variation in its C.P. during its useful life; on the other hand, by increasing the efficiency, complaints on this head will correspondingly increase.

I speak here always of similar makes of lamps under similar conditions. In reference to this point, the Central Institute tests on Edison-Swan lamps seem to show them to have been exceptions, for they are generally credited as giving more than their nominal C.P., viz., a 16-C.P. generally gives 18 C.P. initially. Such a result is very favourable to the maker's name, for in practice such lamps are considered to give 16 C.P., and after burning a stated number of hours, they are reckoned from this standpoint (of 16 C.P.), and after 100 to 200 hours, can thus have nearly their initial (nominal) C.P., and at the end of any period of burning, they will compare most favourably with any other lamp whose initial and nominal candle-power were equal. This same effect can also be brought about by a suitable treatment in flashing, and by under-running on the pumps, as seems to have been the case with the type C lamp of the Ohio University tests.

In further reference to the Central Institution tests, there seem to have been some rather remarkable errors in the photometry. When the mean errors are added or subtracted, and converted into candle-powers, in any particular case the large variations are shown, and they considerably affect the watt per C.P. results.

As the photometer was 200 centimetres long, and a 2 C.P. standard was used, unless some tedious calculations were made, errors must have been caused by the form of photometer used, for when measuring, say 18 C.P. and 5 C.P. the (say) left face of the paraffin block would be much nearer to the 2 C.P. stated, that, say, right

face to the tested lamp, and, therefore, the thickness of the block itself would come into play, as one side would be comparatively nearer its illuminant than the other, whereas distances on the photometer bar, are taken from the centre of the two blocks, and, therefore, for great accuracy, these should be extremely thin if practicable. In fact, owing to this source of error, the "Joly" form of photometer is only strictly applicable to the measurement of C.Ps. when itself and the two lights under comparison are all fixed, but one of the latter has its intensity regulated by reflection, dispersion, &c.

The curves accompanying the above-mentioned tests have no general applicability, and are strictly true for the particular class and kind of lamp under consideration. Every maker must have data for such curves in his possession, especially when supplying lamps of varying efficiencies. In every case the specific resistance of the particular filaments under comparison must be known, and no account seems to have been taken of this in the above tests.

The specific resistance of different filaments in different lamps is by no means the same, and depends upon the material and methods of preparation, and its effect on such curves is very great (other things being equal).

I likewise do not see any mention made (in your extract) of the condition of the vacua in the several lamps under test, for if not perfect, varying results will be likewise obtained.

After perusing all these recent tests, one would be glad to find someone actually testing the true relative and intrinsic merits of various glow-lamps under the only one possible method, viz.: To begin running each lamp under test at exactly the same efficiency in watts per candle-power. This can be done by first re-photometering all the lamps, and thus reducing them to one common efficiency and voltage, irrespective of their candle-powers, and then to run them at this common voltage.

Apart from this method of testing, there is no other that I know of that will give results of any practical value; and intelligent station managers should know by this time that it would pay them (when they find lamps varying from different makers) to re-photometer all their lamps, and not to be contented with such a crudely commercial (*sic*) comparison as that made at the Ohio University.

C. J. Robertson, *Technical Director, Electriche Glühlampen Fabrick "Watt," Vienna.*

Physiological Effects of High Frequency Alternating Currents.

I notice in your issue of July 15th, in commenting on the physiological effects of alternating currents of high frequency, and particularly upon a communication to the Electrical Section of the Franklin Institute by Prof. Houston, you say:—"It is unfortunate, however, that the Professor does not give us some idea has to how far the effect of the same current strength at different frequencies had been taken into account."

About a year and a half ago I published a statement based upon the experiments of Dr. Edward Tatum, of Yonkers, N.Y., which covers the point in question. Dr. Tatum died shortly after making these experiments, and no complete statement of them was ever published, but there certainly was published a sufficient account of his experiments to indicate clearly that alternating currents of a greater strength than continuous currents could be supported by a dog without injury, such currents being passed through the head of the dog. The frequency of the alternating current was above 2,000 or above 4,000 alternations per second.

I believe that Dr. Tatum measured his currents by a hot-wire ammeter. The results of his experiments were to show that the most fatal frequency was about 60, or 120 alternations. I suggested the explanation that as the frequency rose the number of zero points increased, while the duration of the current in any one direction before reversal diminished, and that the effect of this might readily be to save the living molecules, or at least to give them a chance for recuperation. This would be particularly true did they possess any property which would cause them to be sluggish in their response to an electric stimulus.

I can scarcely agree in attributing the comparative immunity experienced with very high frequency currents to what is called "skin effect," for the reason that the conductivities of the tissues vary so widely. If the high period current be assumed to traverse the skin or surface of the body it should produce a much stronger sensation of pain. Dr. Tatum found, however, that there was no particular difference in the sensation experienced at the different frequencies up to 4,500 alternations, and from the fact that the skin of the body is comparatively dry and underlaid with nonconducting fat in greater or less amount, it would seem that until experimental investigation actually proves that "skin effect" has anything to do with this case it rests on mere assumption, I may say, as you remark in relation to another statement of Prof. Houston—"Of course this may be, but the evidence of it is not forthcoming."

It can hardly be claimed that the discharges of great rapidity of oscillation, such as are yielded by a Leyden battery of fair surface, would be harmless if continued for a second or two. In fact, I have found that in my high potential induction apparatus giving long sparks, which represent high frequencies, there is no difficulty in killing a kitten in a few seconds by placing it in the path of the discharge. The death was practically instantaneous. As these discharges are induced in a secondary coil from condenser discharges passed through primary circuits of only a few feet in length their frequency is certainly high enough, and the fact that at each discharge there is a perceptible current flowing would readily account for the result obtained.

Elihu Thomson.
Per J. W. G.

July 27th, 1892.

Storage Battery Traction.

In your issue of July 29th, I observe you insert a letter from Mr. Epstein, relative to his accumulator, and also the report of Prof. Ayrton thereon. There are several points to be considered in electrical traction by means of accumulators, principally weight, size, and durability. In regard to weight, I find, upon reference to Mr. Niblett's book on "Secondary Batteries," Epstein's 120 ampère-hour cell, complete with acid, weighs 81 lbs., and the size, 15 inches × 3½ inches × 17 inches = 892½ cubic inches; the question of durability resolves itself into "cost of maintenance," and in reply to this the inventor states, the company with which he is connected undertake to maintain their cells at the rate of 1d. per car mile.

As you will see by the enclosed pamphlet, I am connected with a still better cell, called the "Indestructible," and beg to submit the following comparative statement, based on the foregoing.

	Weight.	Size.				Cost.	Amp. hr.
		in.	in.	in.	c. in.	car mile.	
Epstein ...	81 lb.	15	× 3½	× 17	= 892½	1d.	120 to 150
Indestructible	41 lb.	7¾	× 7¼	× 10	= 547½	½d.	130

We are prepared to submit our cells to any tests, and also to guarantee the maintenance above mentioned.

Mr. Epstein makes a great point of the rough usage to which his cell has been subjected, but even in this particular he is not alone in the field.

The "Indestructible" cell may be charged in two hours for a six to eight hours' run, and discharged as rapidly as desired without risk or injury to the battery.

It has been in the hands of two of the largest electrical firms in England, and after most exhaustive trials extending over several months, it was declared to possess the following advantages over all others, viz.:—

Greater efficiency;
Smaller dimensions;
Less weight;
Greater durability;
Less cost of maintenance;
Cannot be over charged or over discharged;

and at their hands received its baptismal appellative.

For fear your readers should be under the false impression that the Epstein cell is the nearest approach to perfection, I shall be pleased if you will do me the honour of inserting this letter in your next issue.

Henry Pynegar.

August 3rd, 1892.